Vintage Synth Lab
AWM-3 Operation Manual ver: AWM-3_OM_ver0.8 (2017-04-10)

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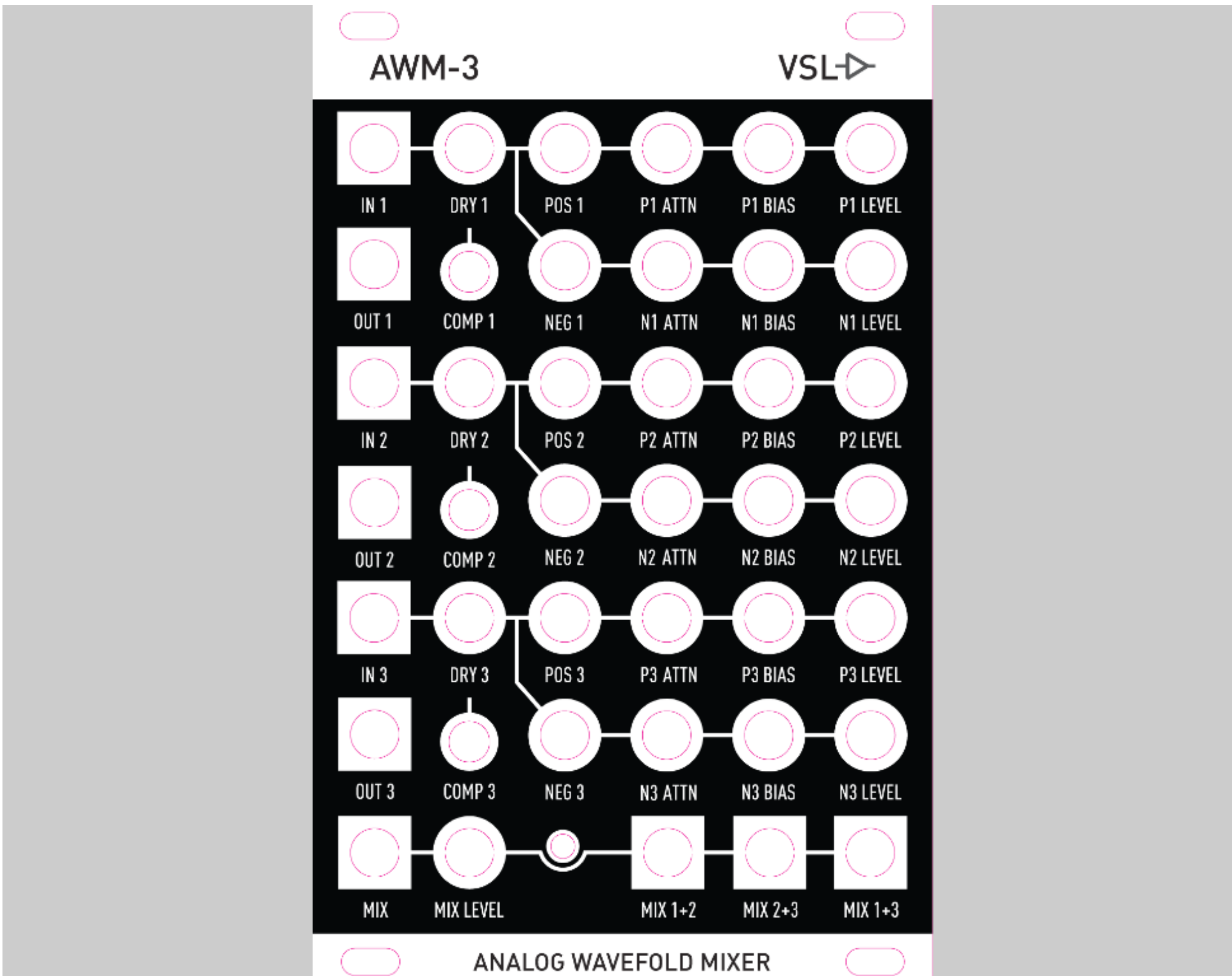
The AWM-3 (**Figure-1**) is a 16hp Eurorack waveshaper, mixer, compressor, buffer, amplifier with up to +6dB of gain—or twice the incoming signal level. The main feature of the AWM-3 is a 3-channel Analog Wave-fold Mixer. All three channels are independent of each other and can be cascaded to produce double and triple wave-folding.

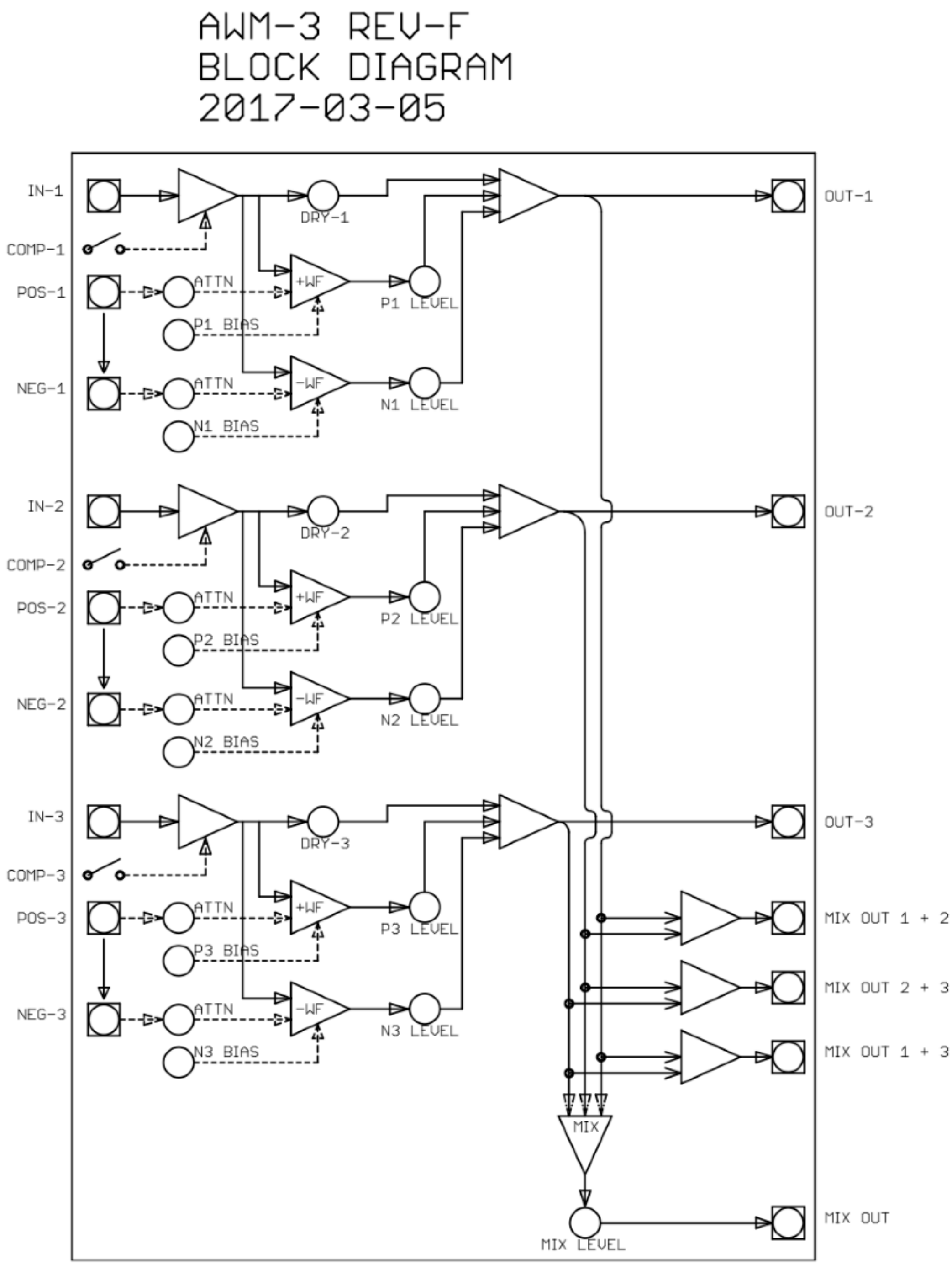
Figure-1



The AWM-3 is a sophisticated, flexible wave-shaping module with the ability to engage audio compression, wave-folding, and mixing. Wave-folding can be activated manually or automatically (through dynamic control, i.e. using a VCA *before* the initial signal coming in to the AWM-3). Independent CV inputs, offset controls (of CV), and attenuation (of CV) for bias of wave-folding allows for a very wide possibility of wave-shaping opportunities.

The block diagram (see **Figure-2**) illustrates the AWM-3 architecture and signal routing. Understanding how and where the various audio and control signals flow will help your understanding of how the AWM-3 works. Solid lines represent audio signal paths, whereas dashed lines represent control signal paths (i.e. CVs, BIAS control signals, etc.)

Figure-2



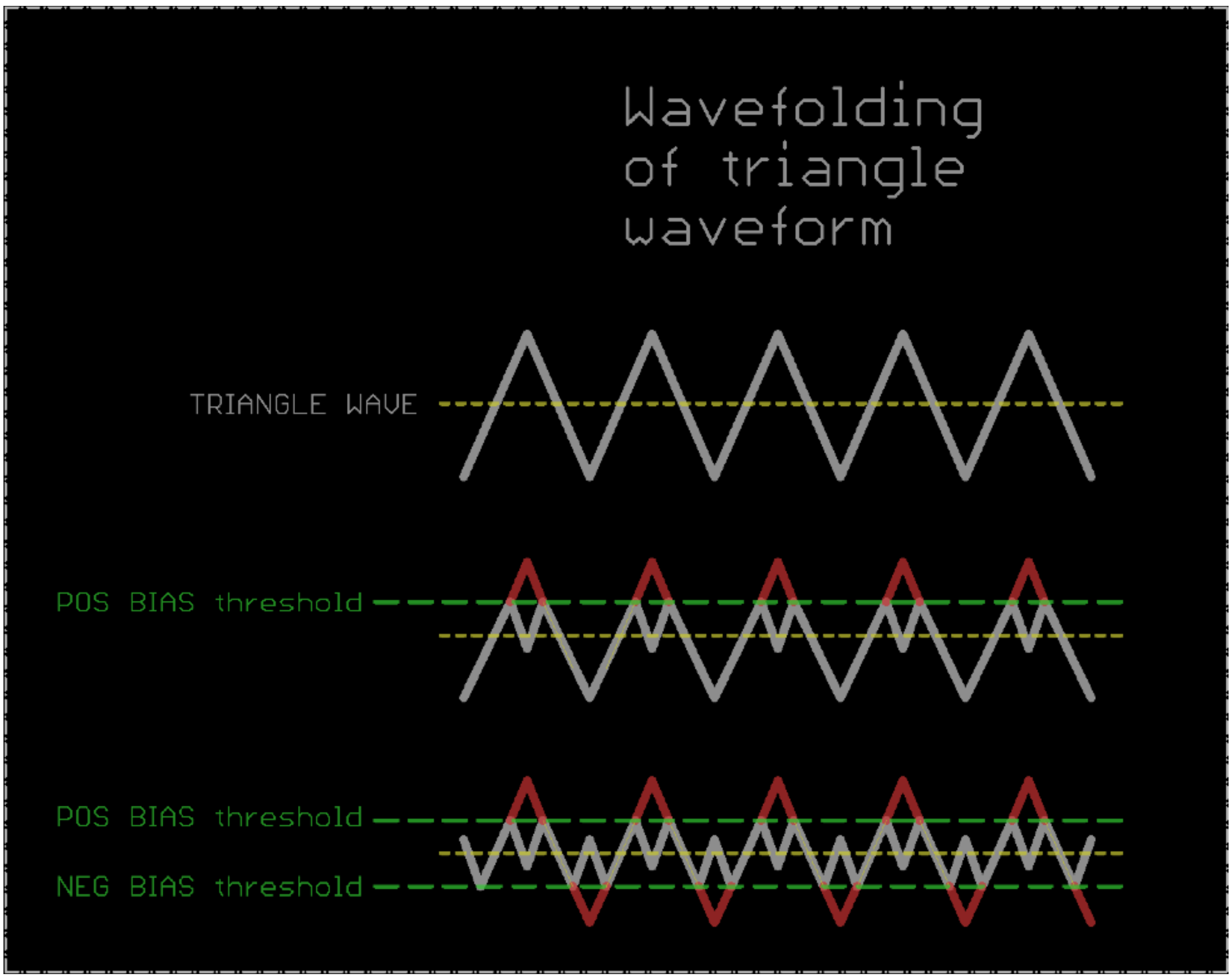
Here are only a few examples of use for the AWM-3:

- single, double, or triple wave-fold / wave-shaping processor
- audio buffer / amplifier / attenuator
- CV buffer / amplifier / attenuator
- audio / CV mixer
- audio / CV matrix mixer, with simultaneous buffered individual channel outputs
- compressor

ABOUT WAVE FOLDING

What is wave-folding? In general, wave-folding is when a *portion* of a wave-form is inverted. See **Figure-3**. Think of it as a slice of the waveform removed, inverted, then added back to the original waveform in the same slice of time.

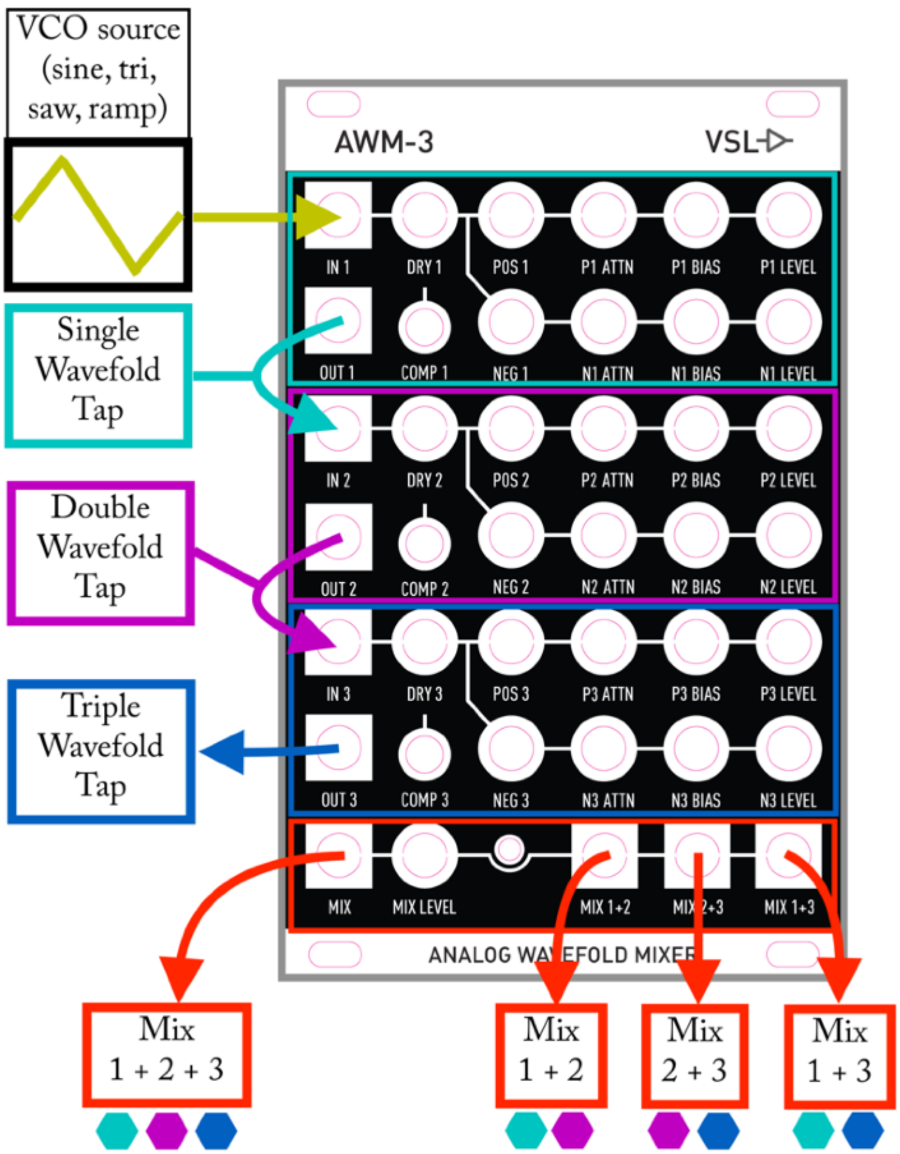
Figure-3



WAVE-FOLDING with the AWM-3 THROUGH CHANNEL CHAINING

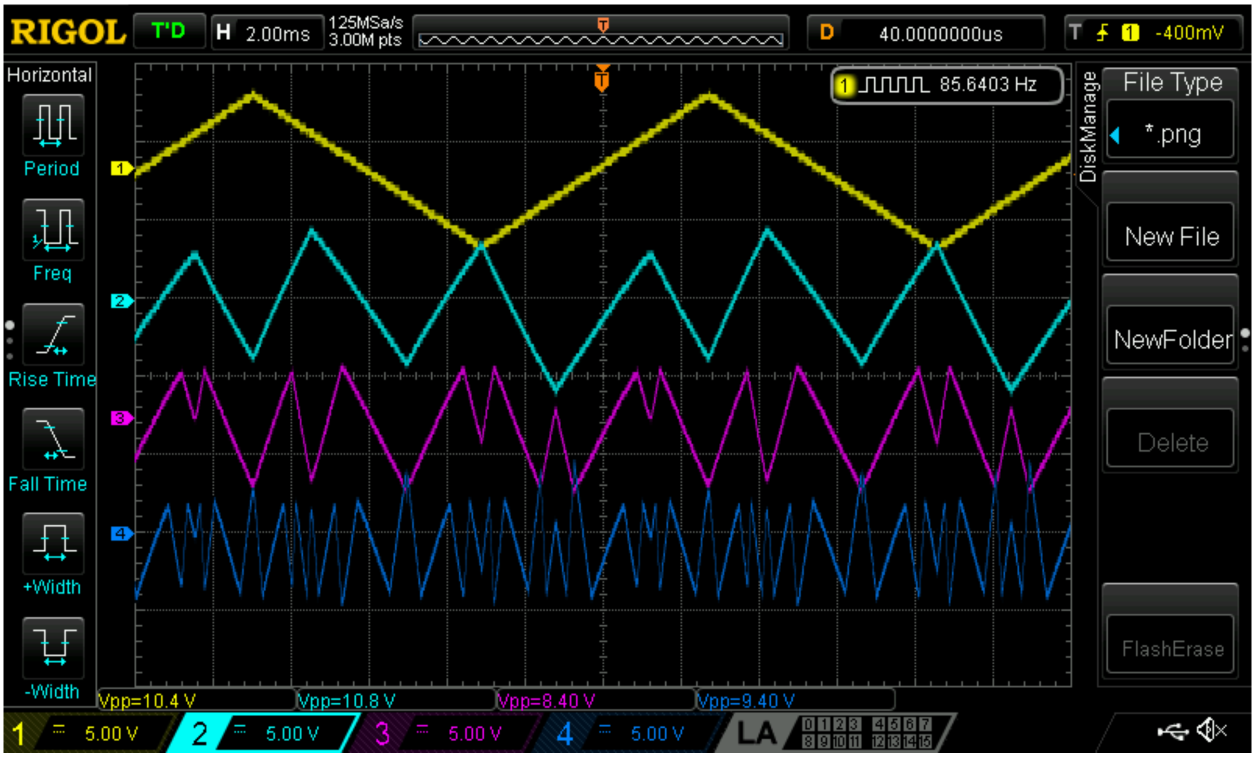
The three channels can be cascaded in series to accomplish a double or triple wave-fold of the original signal routed into IN 1. For example, External Audio source > **IN 1**, **OUT 1** > **IN 2**, **OUT 2** > **IN 3**, and **OUT 3** becomes your serial mix or “triple wave-fold” of the three channels (see **Figure-4 & Figure 5**).

Figure-4



This oscilloscope screen capture shows (**Figure-5**) a triangle wave as the VCO source being fed into the AWM-3, and the various outputs of each wave-fold stage running through the AWM-3. Keep in mind that this is not a fixed wave-fold process, rather it is variable. So this image represents one of infinite possibilities of wave-shaping!

Figure-5



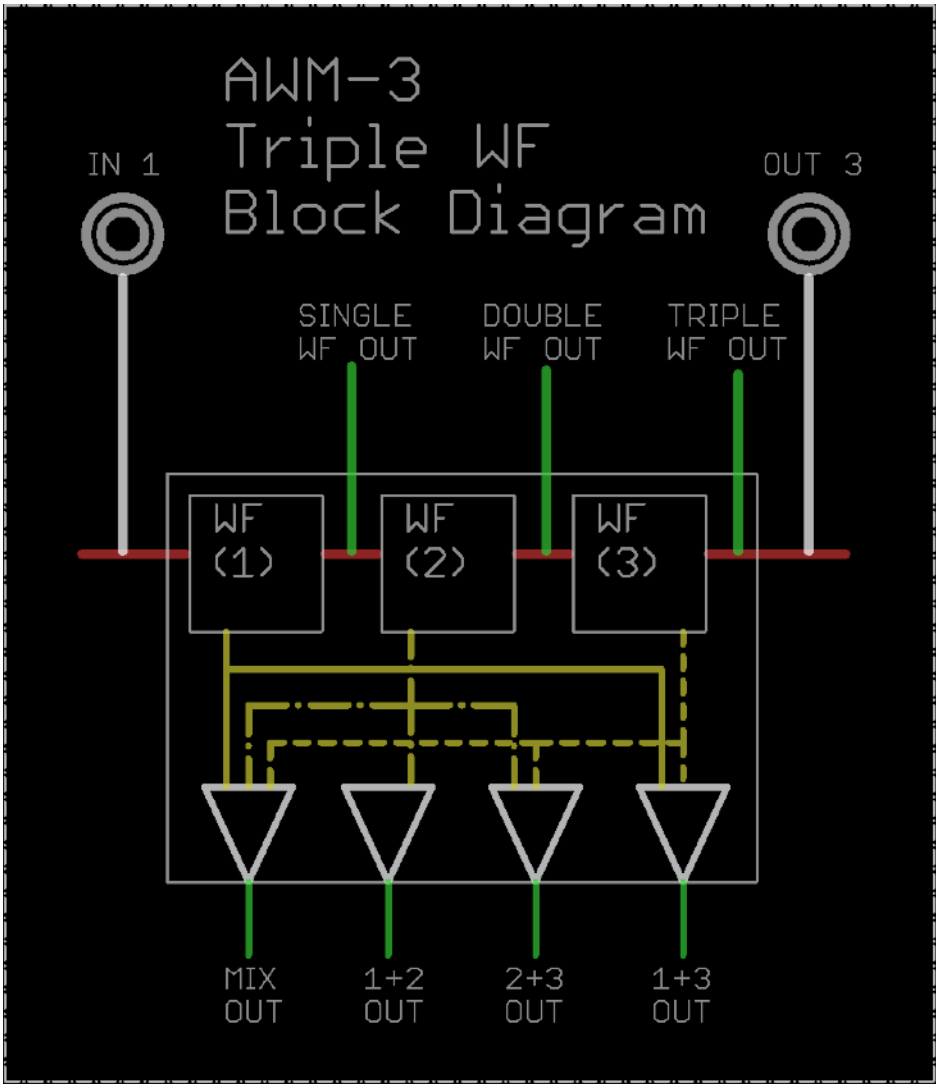
Yellow = VCO triangle source, Light-Blue = OUT 1, Violet = OUT 2, Dark Blue = OUT 3

While the "**OUT 3**" jack provides the triple wave-fold tap (when all three channels are cascaded), as a "serial mix", the main **MIX** out jack provides a "parallel mix" of all three channels' outputs (see **Figure-6**).

The "serial mix", in the case of series connecting channels to get double or triple wave-folding, is analogous to a chain of guitar effects pedals. The way you manipulate or control each effect will have a profound influence on the sound, which is usually compounded downstream (each subsequent effect pedal in the chain).

*The "parallel mix" is no different than a standard mixer. For the **MIX** output jack, the final product of all channel outputs of "**OUT 1**", "**OUT 2**", and "**OUT 3**" are mixed together evenly. However, you do have control over the individual channel sends, simply by maintaining the desired levels of each channel's "**DRY**", "**P# LEVEL**", and "**N# LEVEL**" controls (# = channel number).*

Figure-6



It should be emphasized, that all three channels' "**DRY**" level control pass a unity gain signal when set to approximately the 2 or 3 o'clock position. However, when the level in increased to maximum, the signal is essentially doubled in amplitude (+6dB). One benefit for having up to +6dB of gain (per channel) is that when wave-fold processing occurs, the positive and/or negative peaks of the signal become folded in on itself. The overall signal level (amplitude) is therefore attenuated. In order to compensate for this, the level controls on the AWM-3 provide enough gain to allow for recovery to the standard Eurorack signal level of approximately 10V peak-to-peak, or "10Vpp". Wave-folding occurs when the signal being received by a channel meets a certain threshold—determined by the **BIAS** controls (also known as an "offset" for wave-fold threshold). Bias controls are labeled "**P1 BIAS**", "**N1 BIAS**", "**P2 BIAS**", "**N2 BIAS**", "**P3 BIAS**", "**N3 BIAS**". For example, "**P1 BIAS**" sets the positive wave-fold threshold for Ch 1. Rotating this control *clockwise*, allows the positive side of that channel's waveform to be folded at a *lower* threshold so that the folding process occurs sooner (or is more aggressive). Conversely, the negative wave-fold is controlled in the same manner.

The amount of wave-folded signal mixed back into that channel's output is determined by the two LEVEL controls, "P1 LEVEL" and "N1 LEVEL", as in the example for channel one.

Both positive and negative wave-folding can be accomplished either simultaneously, or independently of each other, per channel. If no cables are connected to the CV inputs labeled "**POS 1**", "**NEG 1**", "**POS 2**" … etc.), a standard 10Vpp Euroack signal will fold onto itself as long as the BIAS control is set to allow a wave-fold threshold crossing.

However, when a CV or signal is inserted into the positive CV input jack (such as "**POS 1**", "**POS 2**", or "**POS 3**"), that CV, whether a DC voltage, LFO, or audio frequency, shall set or modulate the bias for *both* POS and NEG wave folding of that channel, in addition to the amount of BIAS control's offset applied. The NEG CV jack is normalled to the POS CV jack when the NEG CV jack is not connected.

Attenuation for the incoming CV applied to wave-fold bias can be achieved by the "**ATTN**" controls adjacent to the CV input jacks.

Other important things to know about wave-folding:

1) Wave-folding can produce waveform levels that clip or distort due to AWM-3 module's amount of amplification necessary to process signals appropriately …which can result in the maximum level that Eurorack signals can be produced at (approximately 22Vpp)! However, there is no need to worry about overloading or damaging other Eurorack modules in your system. The only point is that the AWM-3 is considered an amplifier (not just a processor) due the nature of wave-folding and signal recovery, mixing, etc.

2) Wave-folding is generally best utilized with waveforms that are continuously varying in nature (i.e. sine, triangle, ramp, saw). If you inject a rectangular waveform (i.e. square wave, PW, etc.), the folding process doesn't occur (rather you get inverted waveforms which is not necessarily useful or desirable in most cases).

3) Wave-folding can occur for either static *or* dynamic signals (see **Figure-7** and **Figure-8**). The possibilities are vast with this added feature of compression.

    A. In general, if you plug a VCO of static (or constant) signal (see **Figure-7**) level directly into the AWM-3, the signal will be folded manually, by the front panel controls, for the most part… with the exception of CVs to modulate or control the BIAS of course.

    B. When a dynamic signal (see **Figure-8**) is connected to the AWM-3, wave-folding can be set up so that the folding process is dependent on the incoming signal level, which can be considered an automatic folding process. <u>In this case, the use of a VCA *between* the VCO output and the AWM-3 input is required</u>. An envelope or modulation applied to that VCA (of that incoming signal) will cause "dynamic folding". The AWM-3 can accept signal levels as high as the maximum Eurorack signal level (~24Vpp).

Figure-7 "Static" signal being wave-folded

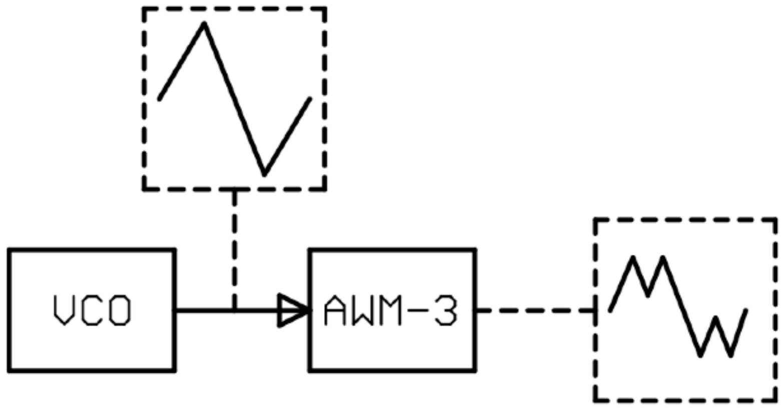
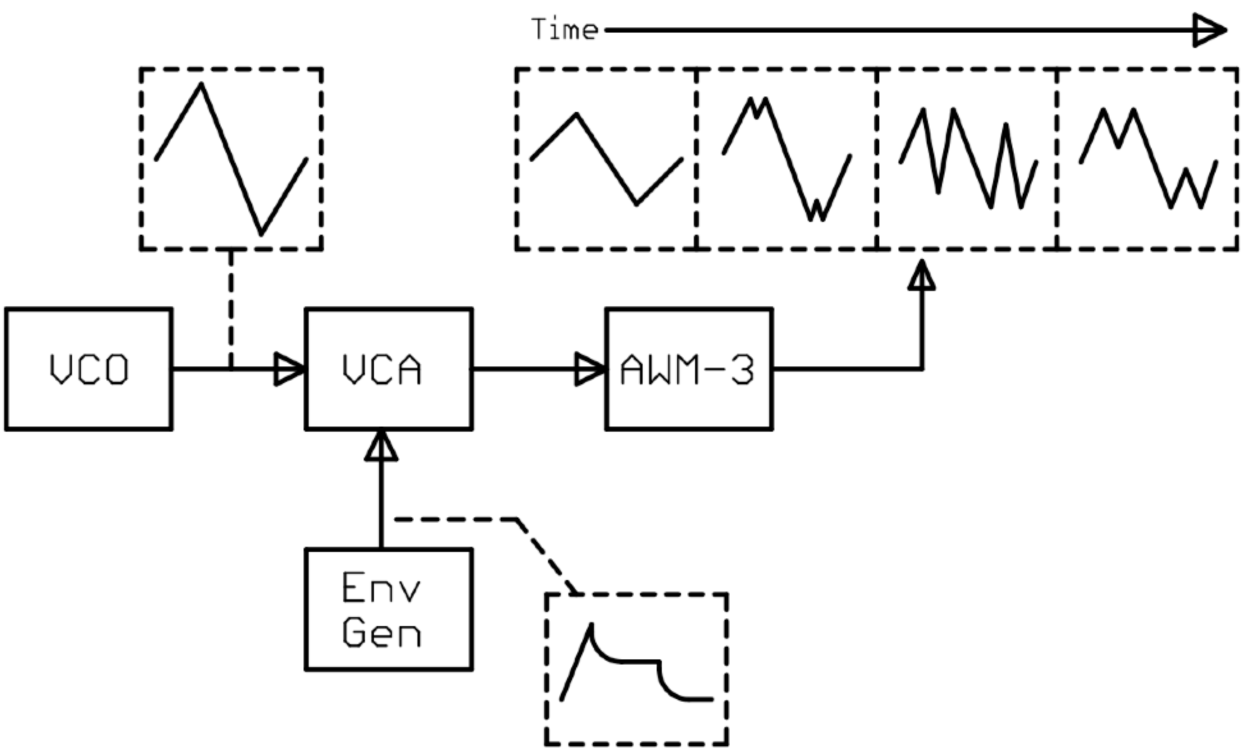


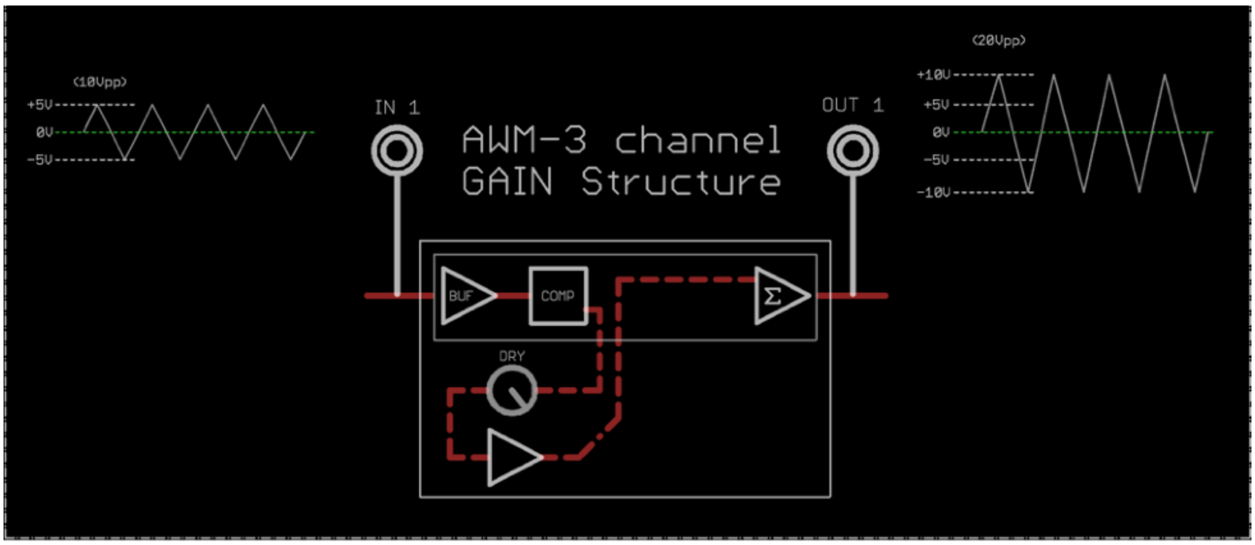
Figure-8 "Dynamic" signal being wave-folded using a VCA between the signal source (VCO) and the wave-fold module (AWM-3)



GAIN STRUCTURE of the AWM-3

The AWM-3 gain structure of a single channel is shown in **Figure-9**. The DRY signal path from IN to OUT of a given channel is variable, from completely attenuated to +6dB (twice the input signal level). **Figure-9** shows a triangle waveform of 10Vpp (10 volts peak-to-peak) patched into the input and with the **DRY** level control set to maximum, a waveform of approximately 20Vpp waveform will output…

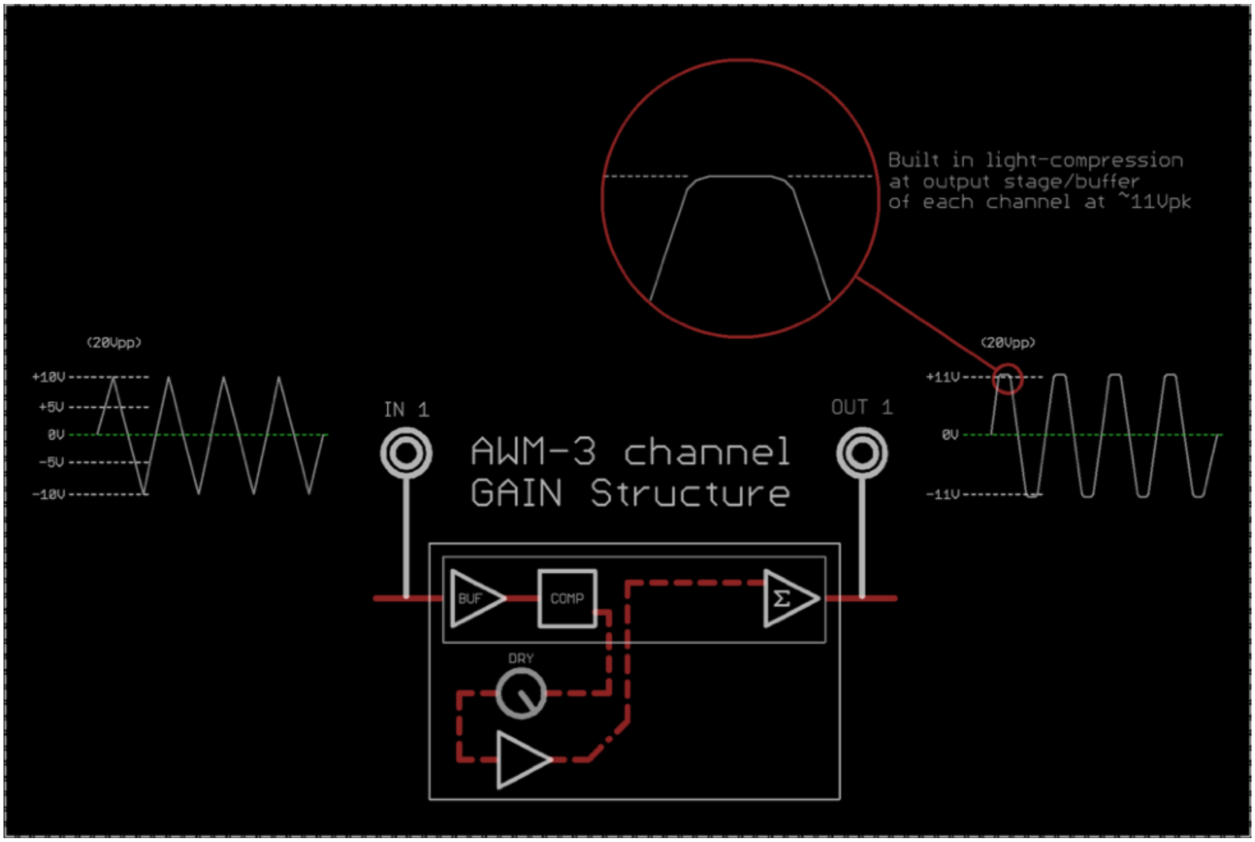
Figure-9



…however, there are some small details about waveforms with levels that approach or exceed this 20Vpp level…

Each channel of the AWM-3 includes an automatic output soft-limiter (see **Figure-10**). This won't prevent your from overdriving the final channel mix stage, however it helps soften the harshness of those levels that are around 20Vpp—about twice the standard Eurorack signal level of 10Vpp. When used as a standard mixer, this soft-limiting would rarely occur. It would be more likely to occur when you have extreme wave folding at high levels passing through the final stage of a given channel… or when you have a VCA ahead of the channel input with high gain.

Figure-10



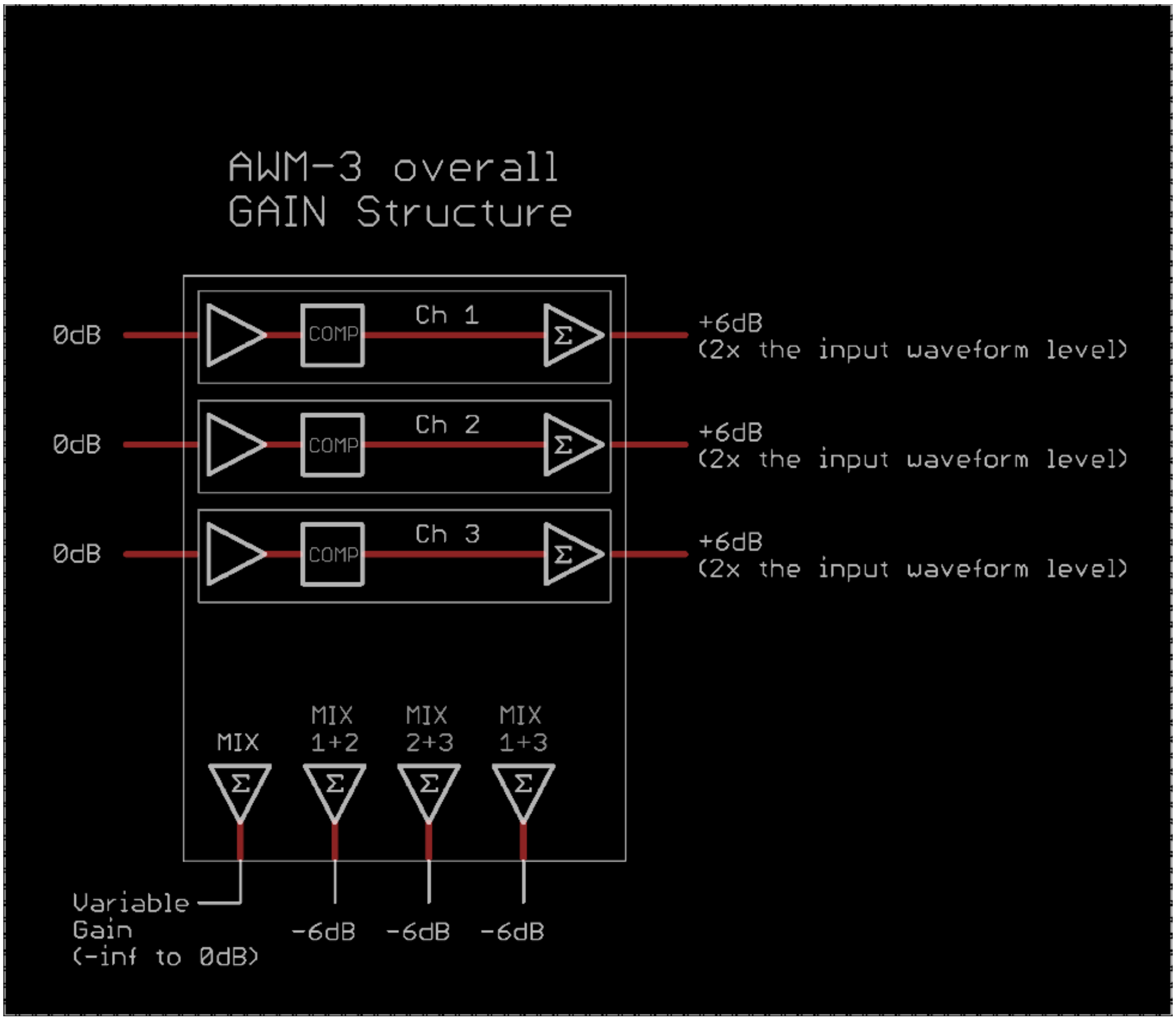
OVERALL GAIN (amplification) and MIXING

The overall gain structure, considering the use the AWM-3 as a mixer is seen in **Figure-11**

The master **MIX** output has a **MIX LEVEL** control that allows you to set a custom level—which also helps prevent overdriving the final mix stage into unwanted distortion.

The matrix-mix outputs (**MIX 1+2**, **MIX 2+3**, **MIX 1+3**) are all of a fixed gain at their final mixing/ buffer stages. The gain of this stage is -6dB (2:1 ratio gain). When two channels are driving a matrix-mix output, the resultant gain brings the matrix-"mix" of the two signals back to 0dB (unity) for maintaining a correct signal level for typical audio levels of Eurorack. It also reserves headroom and thereby reduces the chances of unwanted distortion.

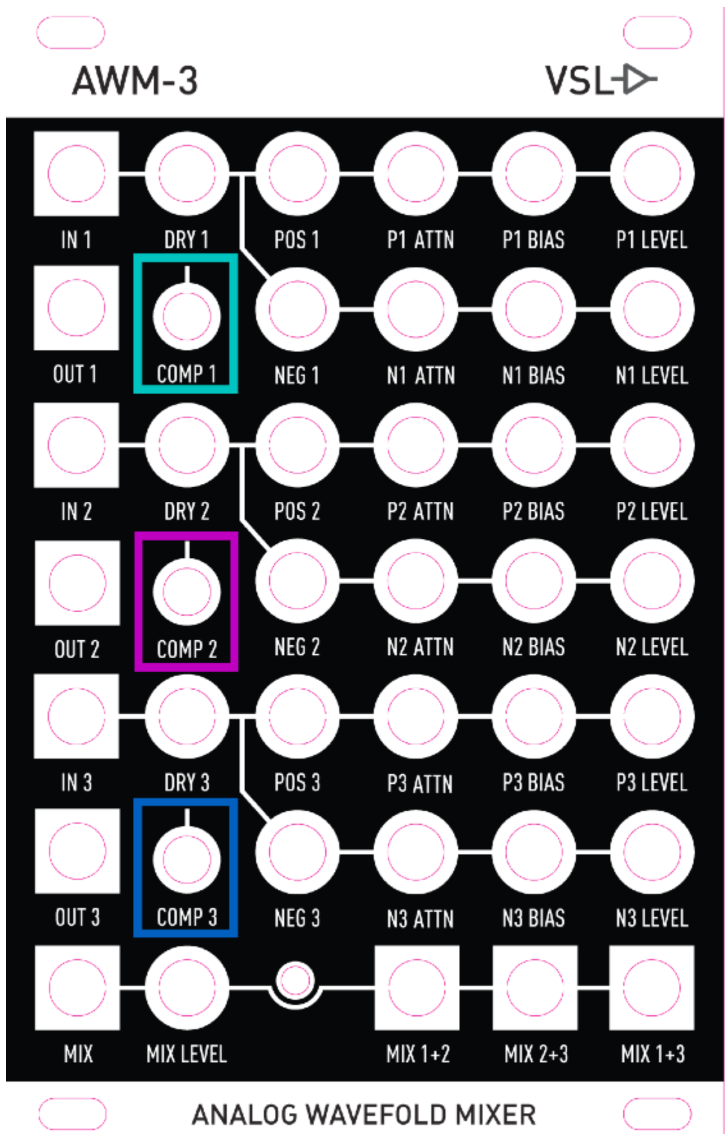
Figure-11



ABOUT THE COMPRESSION FEATURE

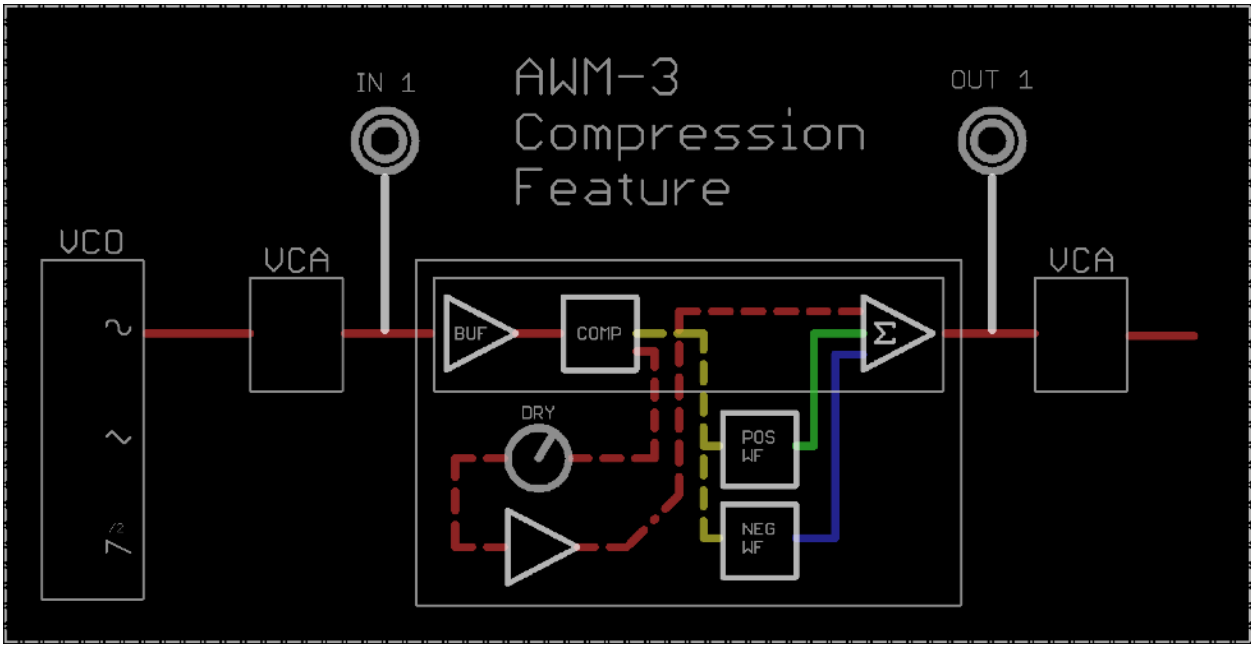
The AWM-3 incorporates the use of a switchable compressor feature. Each channel has an independent toggle switch that enables or disables the compression (see **Figure-12**). While you can engage or disengage the compression feature, the threshold and ratio are fixed, but are optimized for the AWM-3 architecture considering the typical signal levels of Eurorack modular synthesis. We took extra care in emphasizing a balance between the wave-folding process and sonic character, as well as signal levels when designing this compression feature. This compression will tend to “round out” or “soften” the peaks of the signal passing through the first buffer stage of each channel. This signal is then split up and passed to both the DRY signal path, and the wave-fold path. The result is a remarkably different set of wave-shaping, whether used as a wave-fold processor, or a simple mixer.

Figure-12



It is important to note that the design of the AWM-3 is such that the compression occurs *before* any gain controls or processing. In other words, all level controls are post-compression (after the compression circuit). See **Figure-13**, and also refer back to **Figure-2**, the main AWM-3 block diagram.

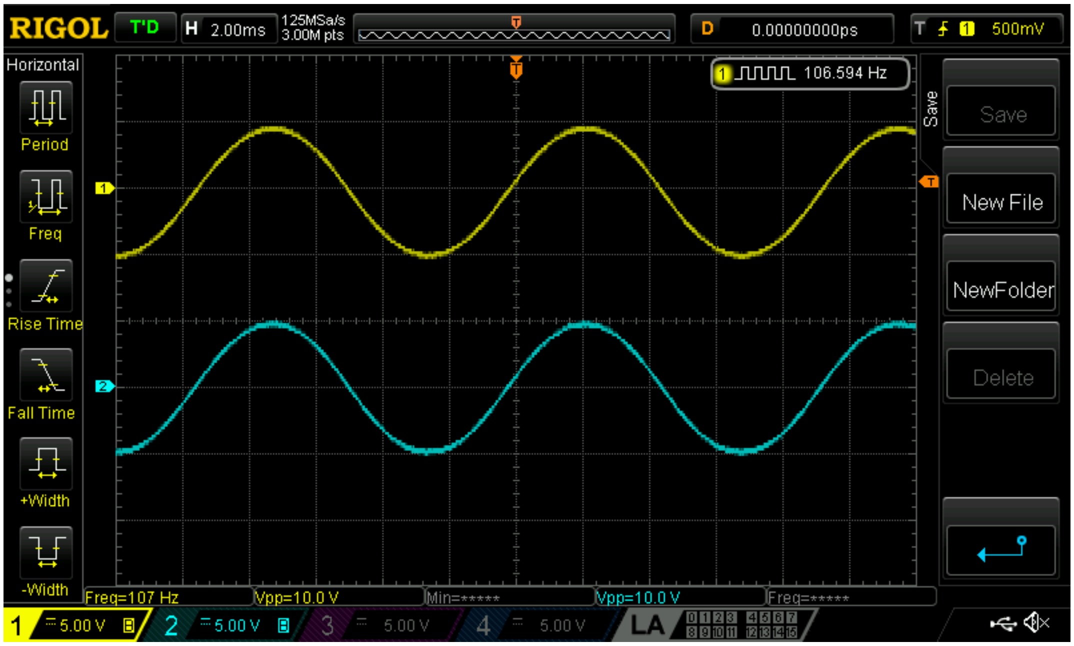
Figure-13
(internal signal routing of a single channel. Emphasis on the compressor before all signal paths)



Let's now take a look at several screen captures of an oscilloscope displaying various input versus output levels, with various DRY control levels, and with both compression enabled and disabled. Here is where some of the wave-shaping starts to happen, even before the wave-fold process occurs!…

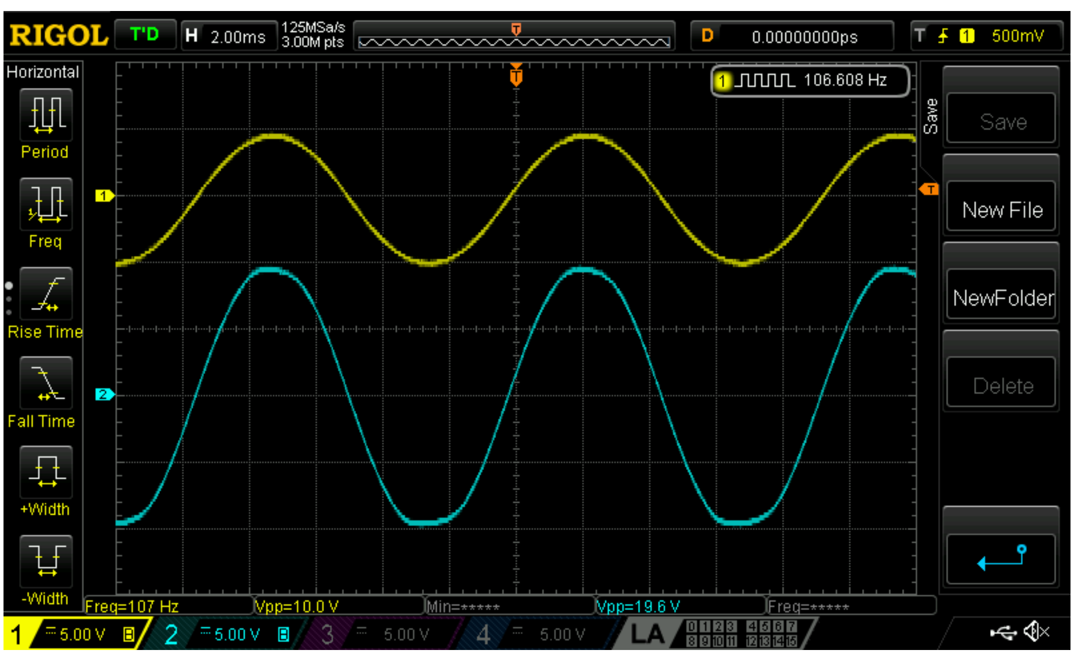
In **Figure-14A**, the trace (in yellow) is the input signal into a single channel. The output signal (the light blue trace) is also shown. In this scenario, there is no wave-fold processing, only the **DRY** level control is set to about 2 or 3 o'clock position for unity gain.

Figure-14A



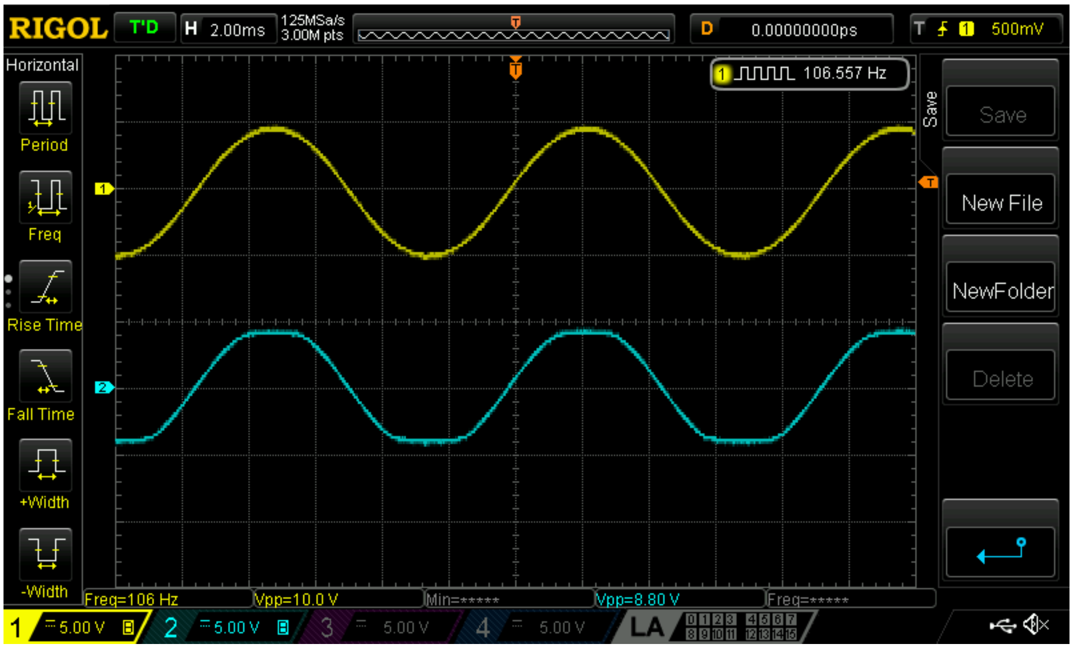
In **Figure-14B**, the **DRY** level is now set to maximum. Note that this is a +6dB increase in signal level. However, we designed a "*light compression*" stage at the output of each channel in order to help improve waveform / audio quality for dynamic waveforms. This light compression stage is fixed and cannot be defeated.

Figure-14B



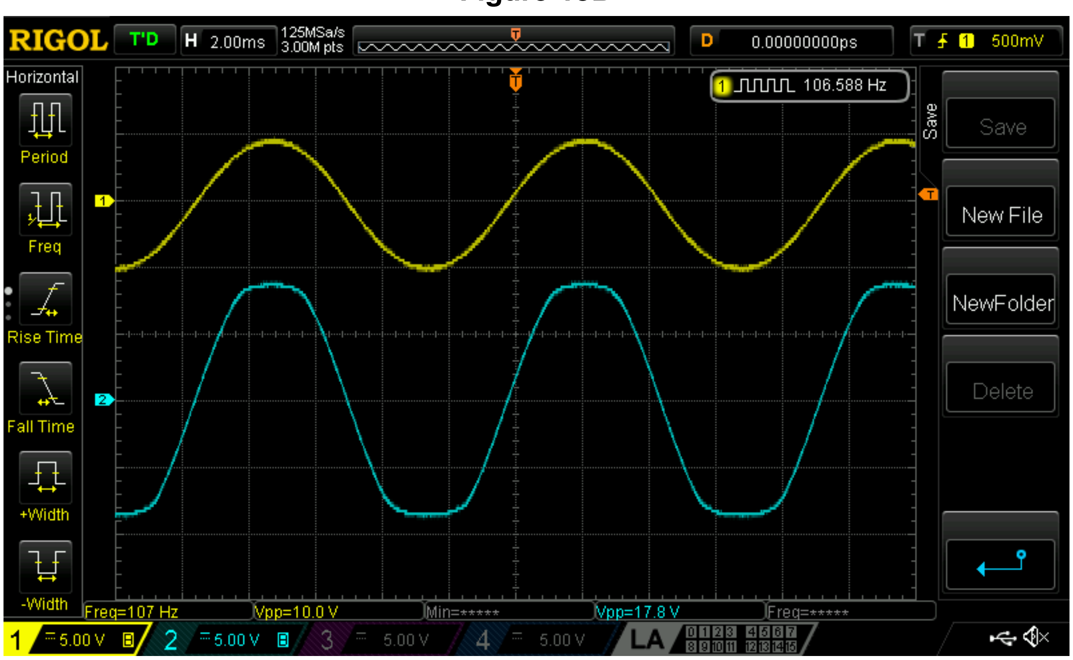
In **Figure-15A**, the **DRY** level is set back to unity (~2:30 position), and the **COMP**ression switch is now engaged. Note that as the incoming signal level is increased (by an external source such as a VCA), the more compression occurs (see also **Figure-16B** on next page). The compression typically engages when the incoming signal reaches a threshold of about 10Vpp.

Figure-15A



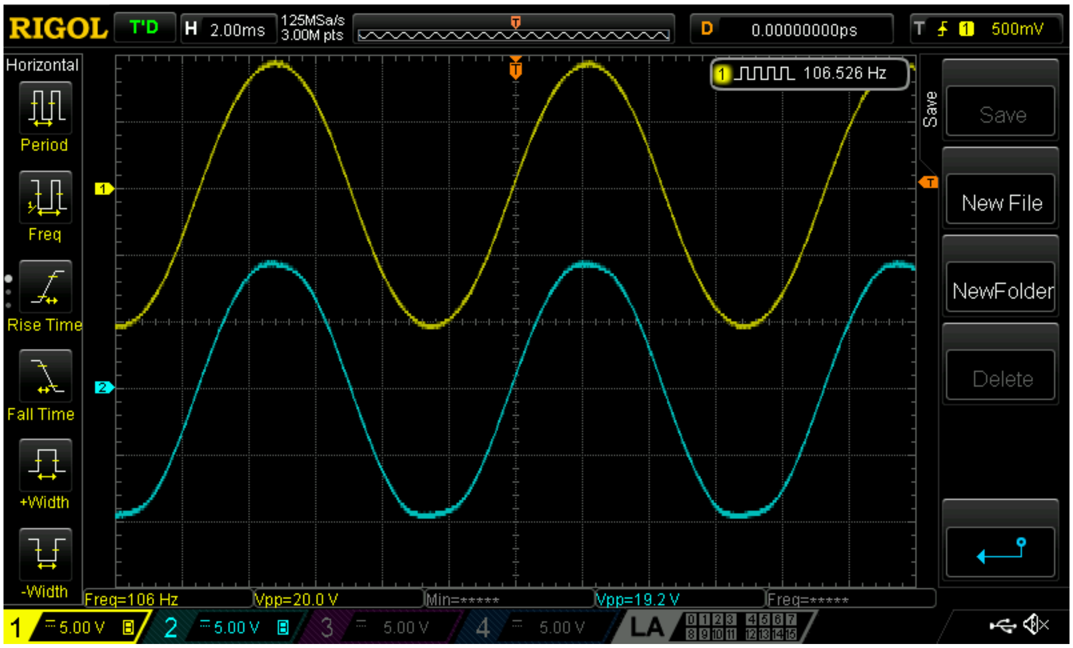
In **Figure-15B**, the **DRY** level is now set to maximum, while the **COMP**ression is still engaged. Remember, the compression is applied *before all signal routing*, so the **DRY** signal level is *post-compression*.

Figure-15B



In **Figure-16A**, the input signal is now 20Vpp (twice that of a normal Euroack signal (this can be accomplished with some VCAs on the Eurorack market), the **DRY** level is set to unity, and the **COMP**ression switch is disengaged. Notice how the fixed output "light" compression is once again starting to occur (blue trace).

Figure-16A

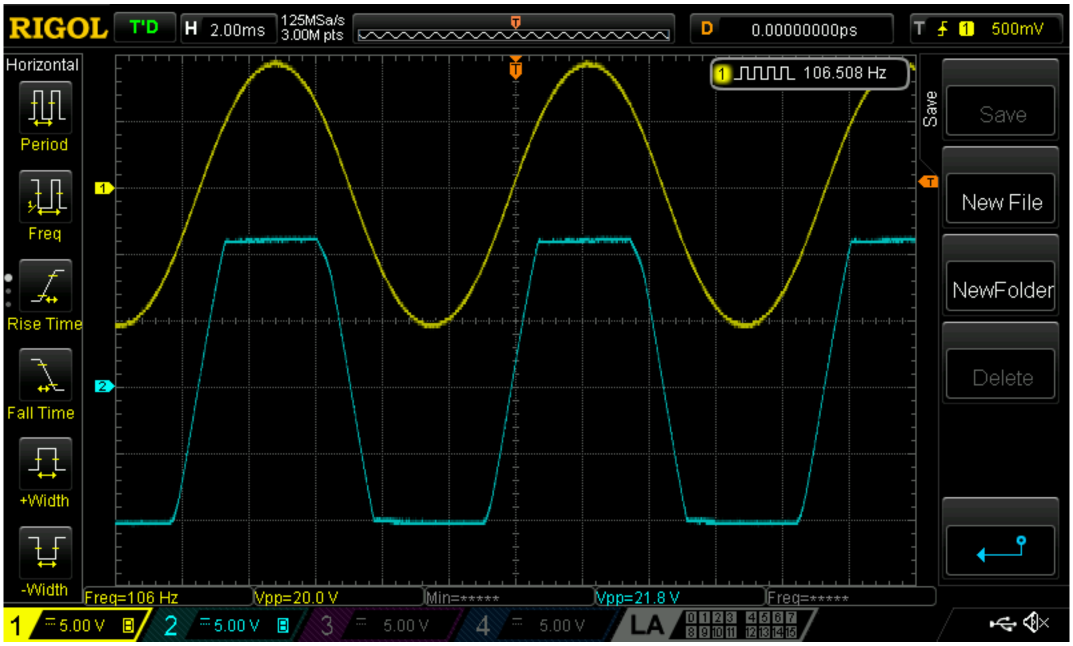


In **Figure-16B**, while input signal is still 20Vpp, and the **DRY** level still set to unity, the **COMP**ression is now engaged.

Figure-16B

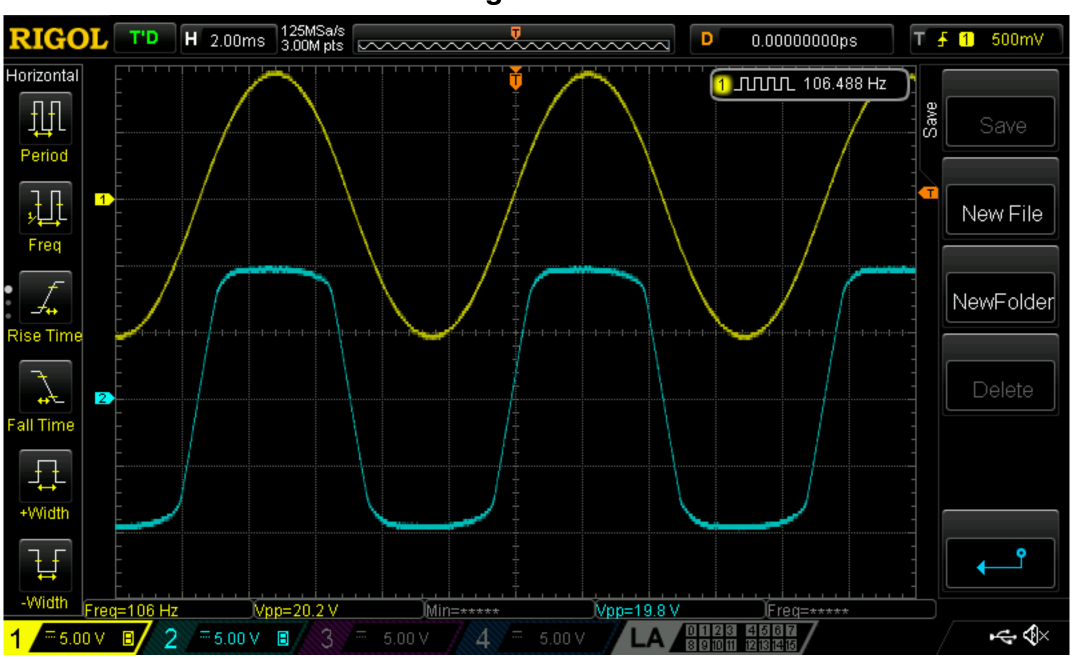
In **Figure-17A**, The **DRY** level is now set to max, and the **COMP**ression is disengaged. (The input signal is still set to 20Vpp). This is a very uncommon scenario, and will of course result in severe distortion that may not be desirable.

Figure-17A



In **Figure-17B**, The **DRY** level is still set to max, and the input signal is still 20Vpp. However, the **COMP**ression is now engaged. Notice the “rounded” clipping much like a vacuum tube or FET circuit.

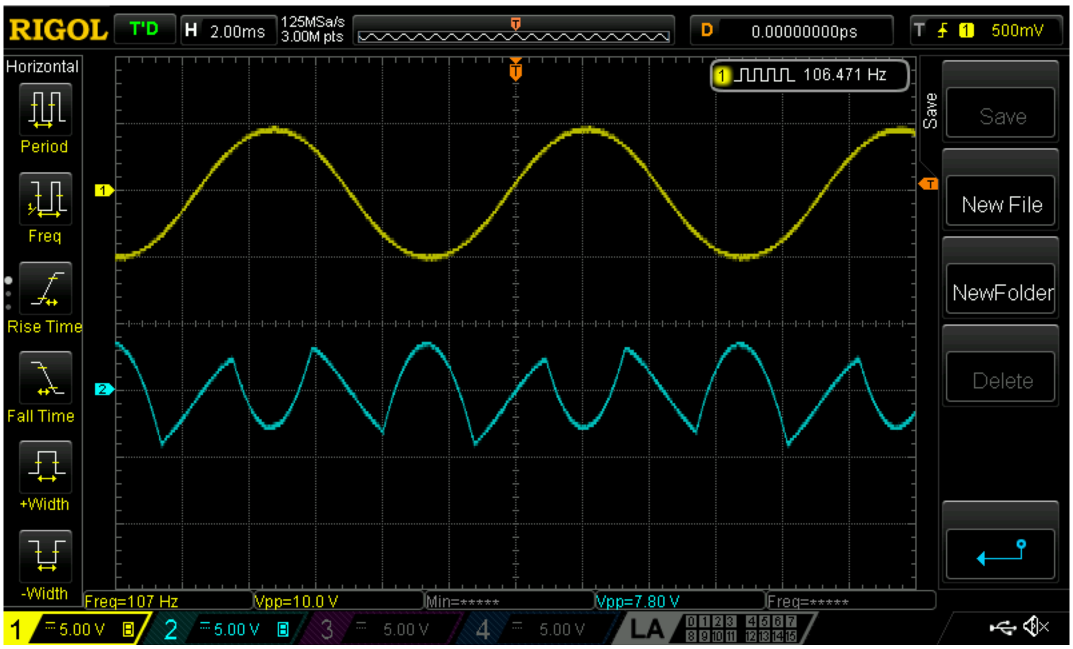
Figure-17B



Now let's take a look at wave-folding, with various gain levels, bias settings, and compression modes…

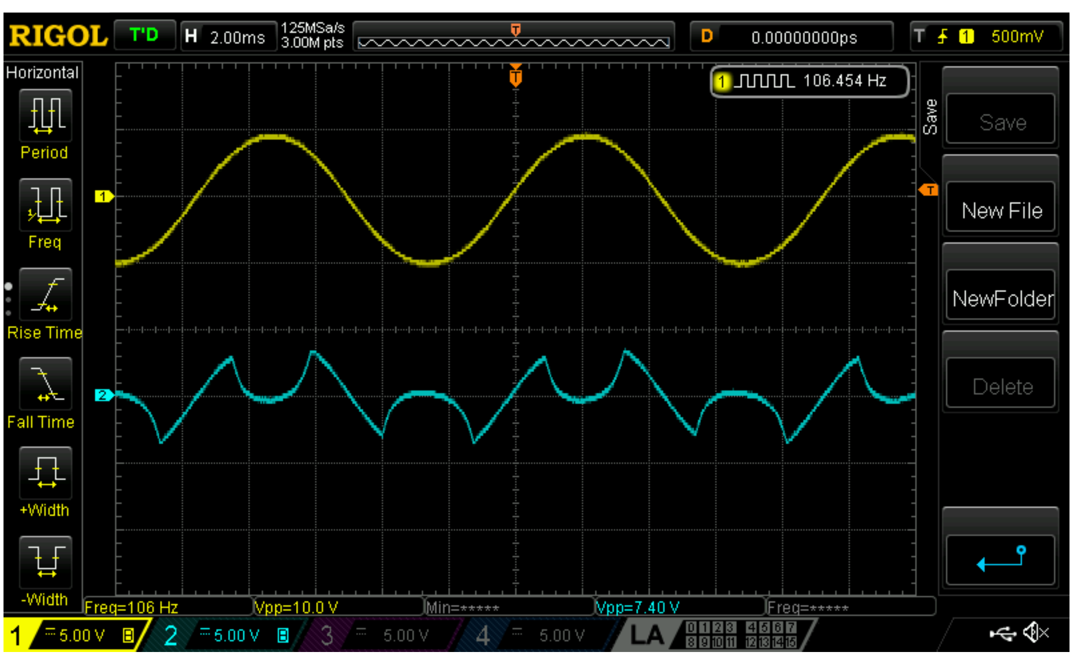
In **Figure-18A**, The **DRY** level is set to unity, the input signal is 10Vpp (standard Eurorack level), the WF (wave-fold) levels are at max, and the biases are both at around the 12 o'clock position. The **COMP**ression is disengaged.

Figure-18A



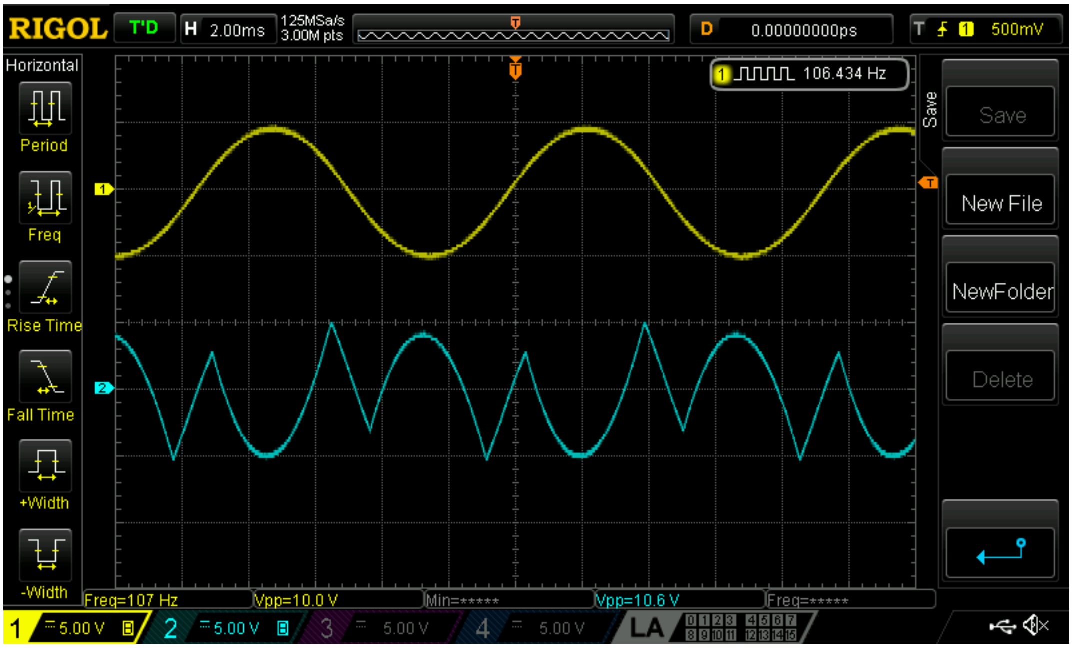
In **Figure-18B**, All settings from the above scenario (see **Figure-18A**) are the same, except the **COMP**ression switch is now engaged.

Figure-18B



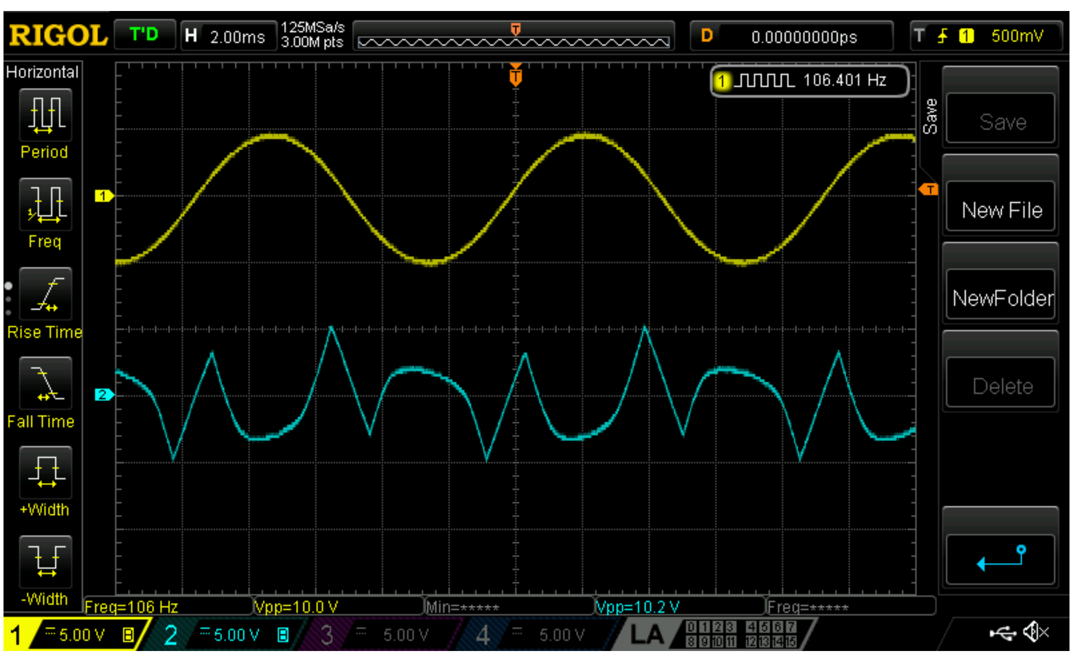
In **Figure-19A**, The **DRY** level is now set to max, the **WF** levels are set to max, the **BIAS**es are set to about the 2 o'clock position, and the **COMP**ression is disengaged.

Figure-19A



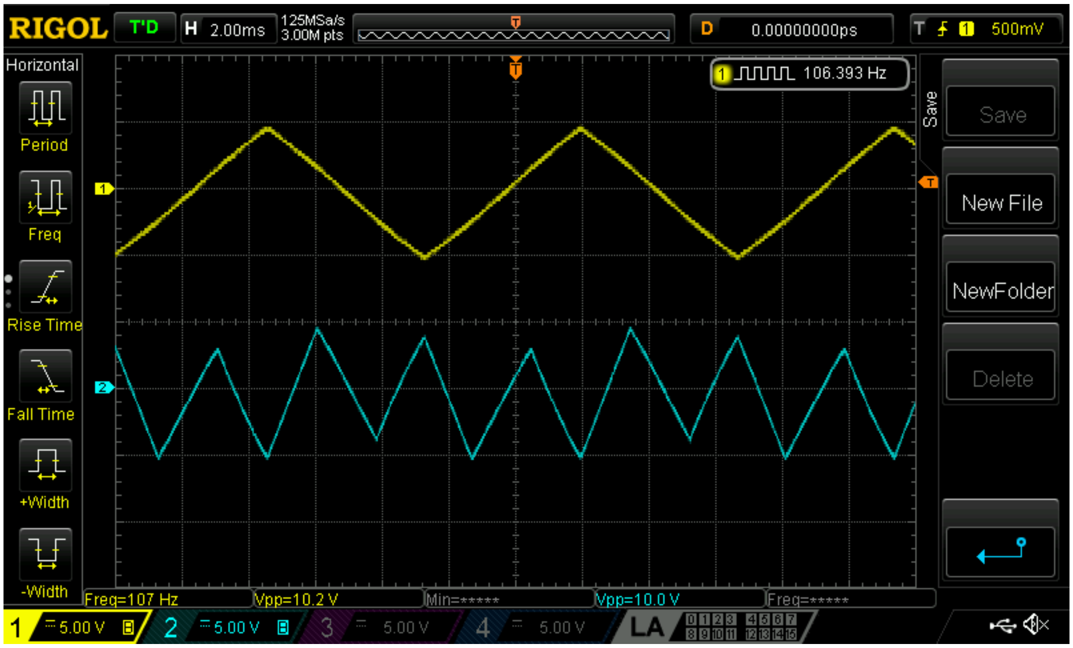
In **Figure-19B**, All settings from the above scenario (see **Figure-19A**) are the same, except the **COMP**ression switch is now engaged.

Figure-19B



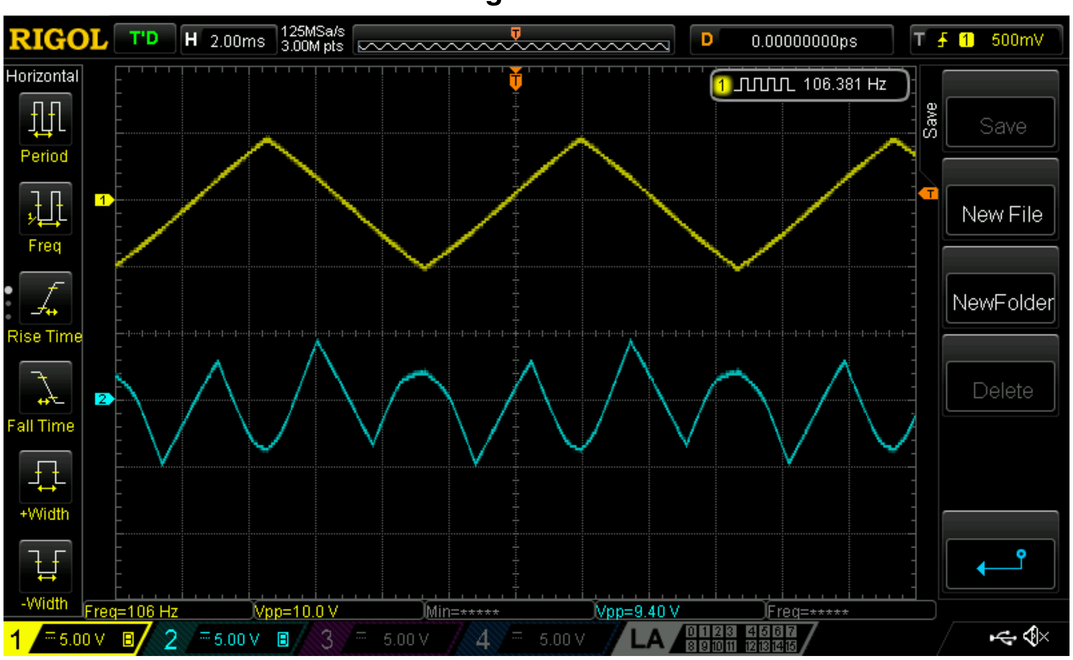
In **Figure-20A**, The same setup is used as in Figure 19A, except that a **triangle** wave is used as a signal source.

Figure-20A



In **Figure-20B**, All settings from the above scenario (see **Figure-20A**) are the same, except the **COMP**ression switch is now engaged. Notice how the compression starts to *shape* the triangle wave. The amount of wave-shaping depends on the level of the signal coming into the AWM-3. The higher the amplitude (especially above 10Vpp), the more compression occurs.

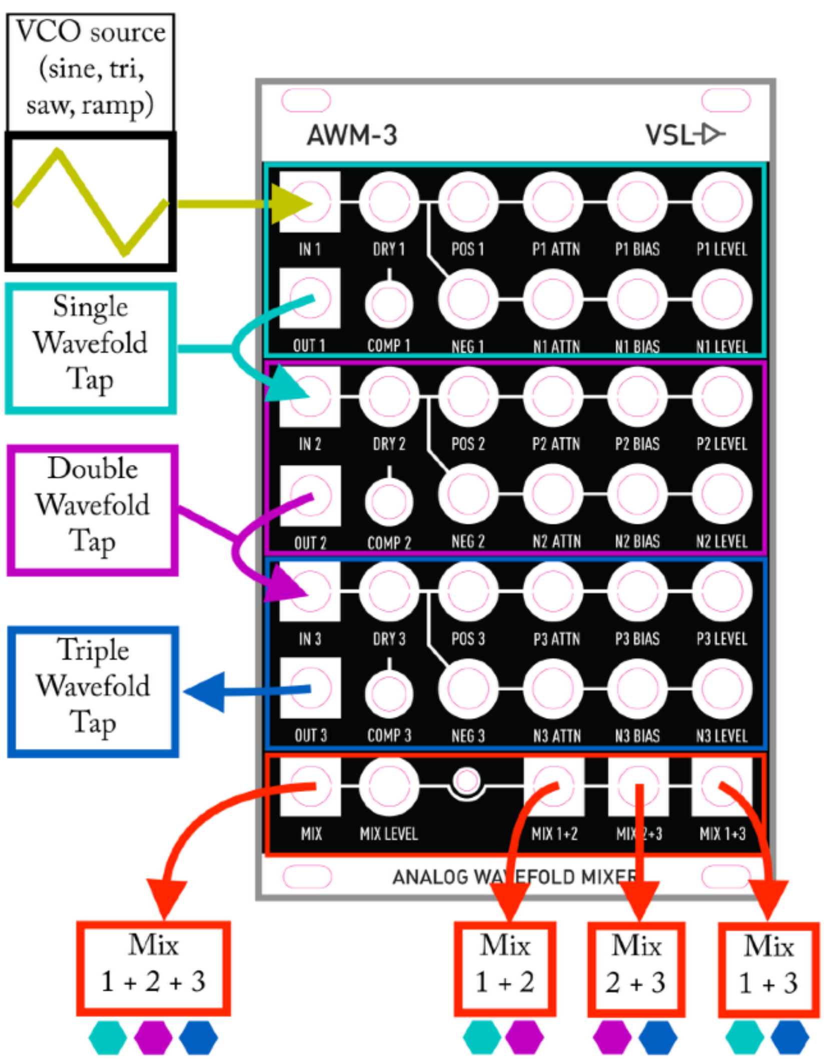
Figure-20B



This is a good moment to reinforce the concept of “static wave-folding” versus “dynamic wave-folding”… refer back to **Figures 7 & 8**. The above examples of wave-folding show “static” signals, meaning that while they are being processed, the incoming signal level remains constant (not changing in level). A video would be more appropriate to demonstrate “dynamic wave-folding” since it requires time to illustrate dynamics in general. In that case, you can find examples within some of our AWM-3 audio/video demos on our YouTube channel at: https://www.youtube.com/playlist?list=PLxPMNFzg8bgY1VvC2JnkwXc70v1GCPb_s

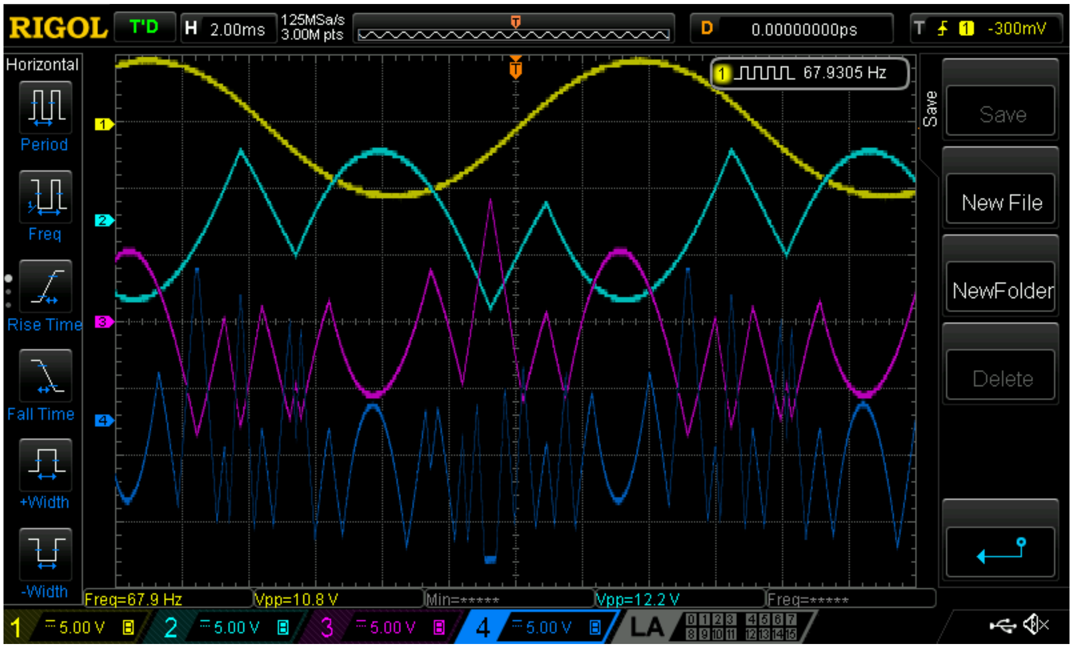
Now, let’s take a look, again, at the basic configuration for multiple wave-fold stages (double and triple wave-folding). See **Figure-21A through Figure 21E**. A signal source such as a VCO is inserted into Ch 1, the output of Ch 1 is patched into the input of Ch 2, and the output of Ch 2 is patched into the input of Ch 3. The output of Ch 2 becomes your double wave-fold output, and the output of Ch 3 becomes your triple wave-fold output. However, the AWM-3 does require some setting up, since this is a pure analog module with extensive control over many parameters.

Figure-21A



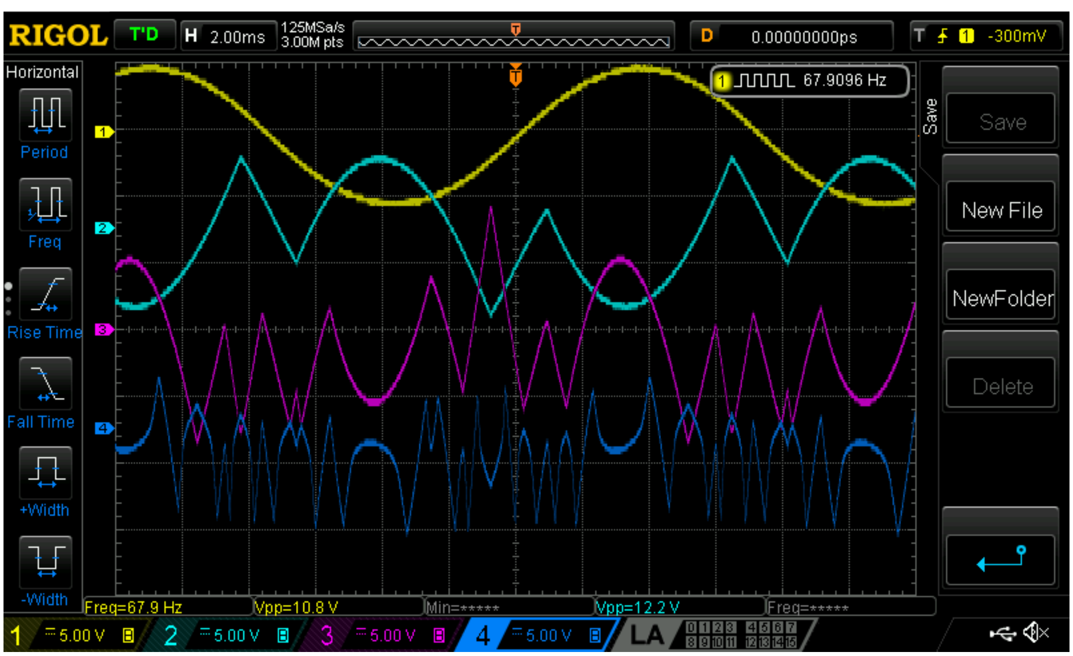
In **Figure-21B**, all wave-fold stage outputs are seen. The top (yellow) trace shows the input signal *before entering the AWM-3,* (for reference). All **COMP**ression switches are <u>disengaged</u>.

Figure-21B



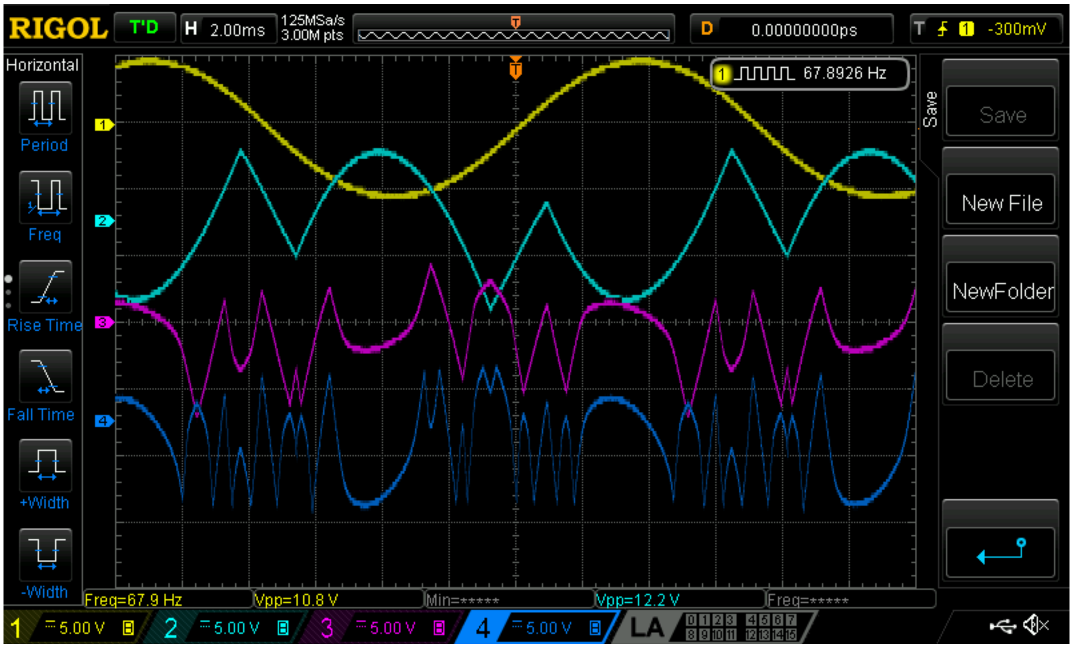
In **Figure-21C**, the **COMP**ression switch for the last stage (channel 3, dark blue trace) is now <u>engaged</u>.

Figure-21C



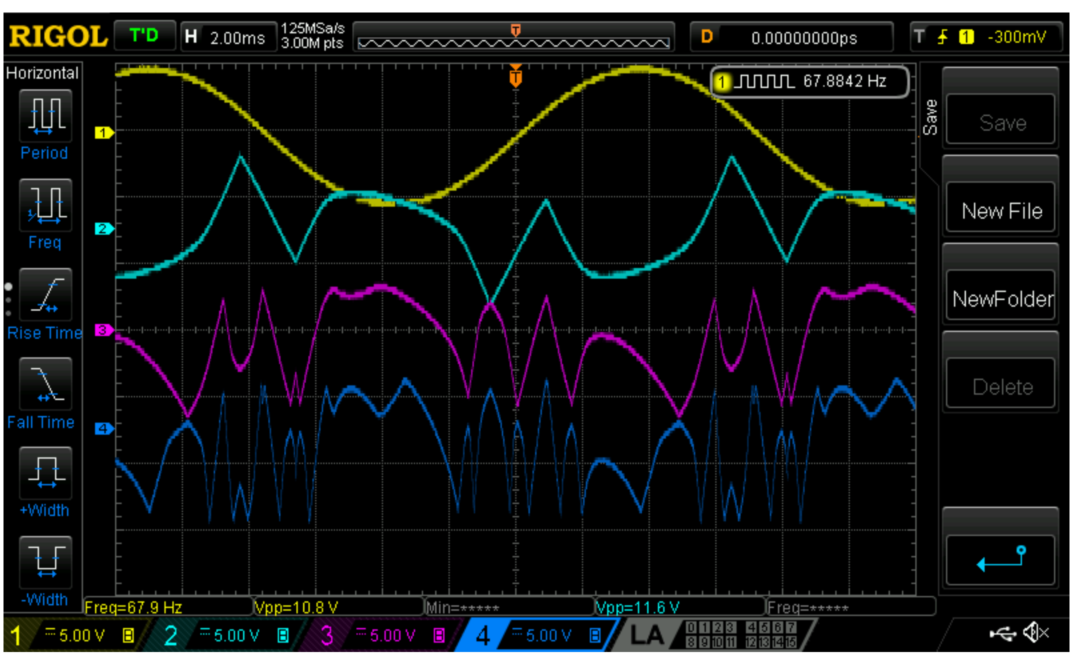
In **Figure-121D**, the **COMP**ression switch for the second stage (channel 2, violet trace) is now engaged. Notice how the compression compounds its effect on the signal downstream (channel 3, dark blue trace)

Figure-21D



In **Figure-21E**, the **COMP**ression switch for the first stage (channel 1, light blue trace) is now engaged. Again, notice how the compression compounds its effect on the signal downstream.

Figure-21E

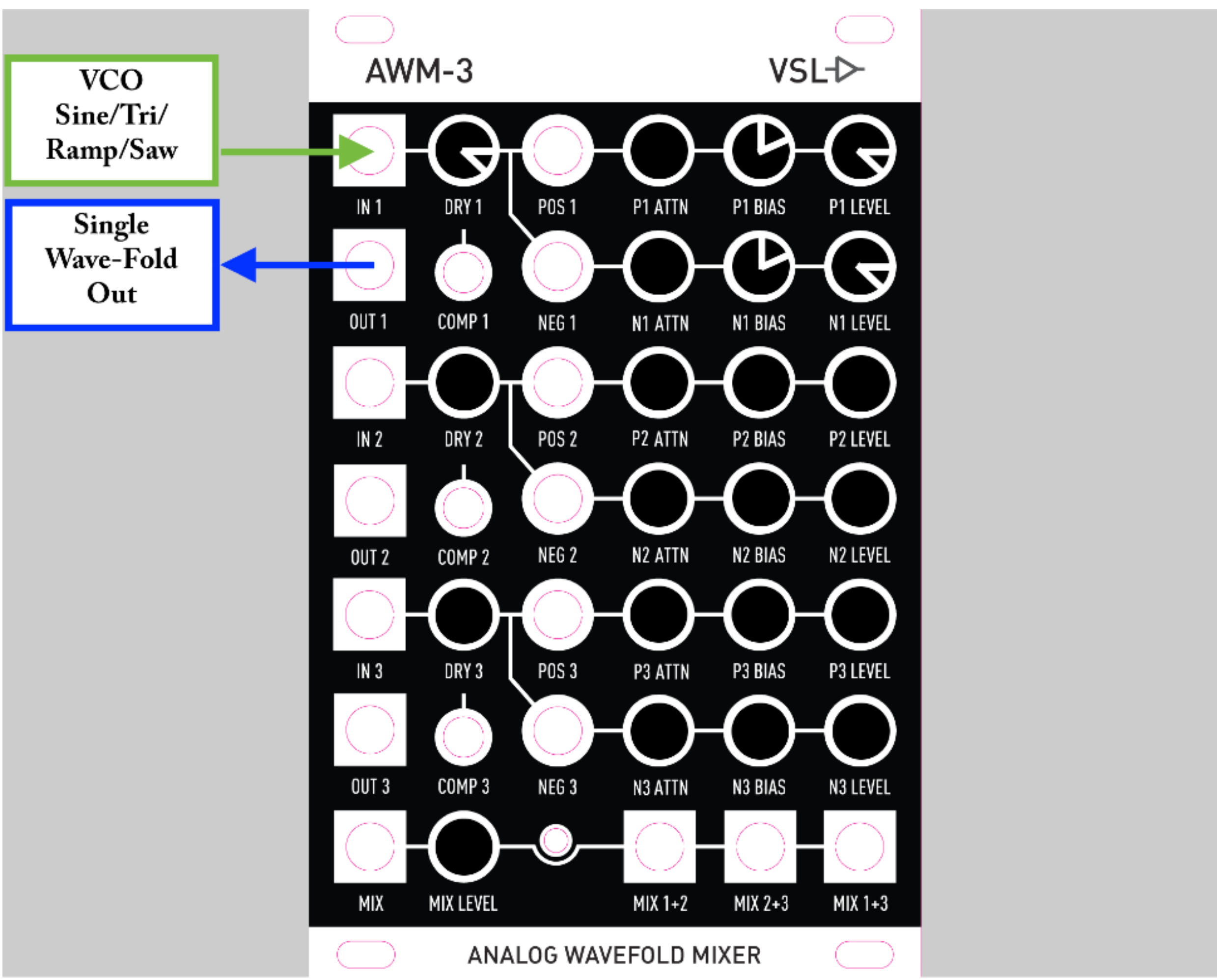


AWM-3 Extended User Guide setups (Configurations) for various effects…

The following setups and connections are only a few of many different configurations that can be arranged with the AWM-3 in a modular synthesis system to derive a variety of effects. Some configurations require the use of external VCAs, LFOs, Envelope Generators. This guide assumes the presence of those basic building blocks of a modular synth in your system.

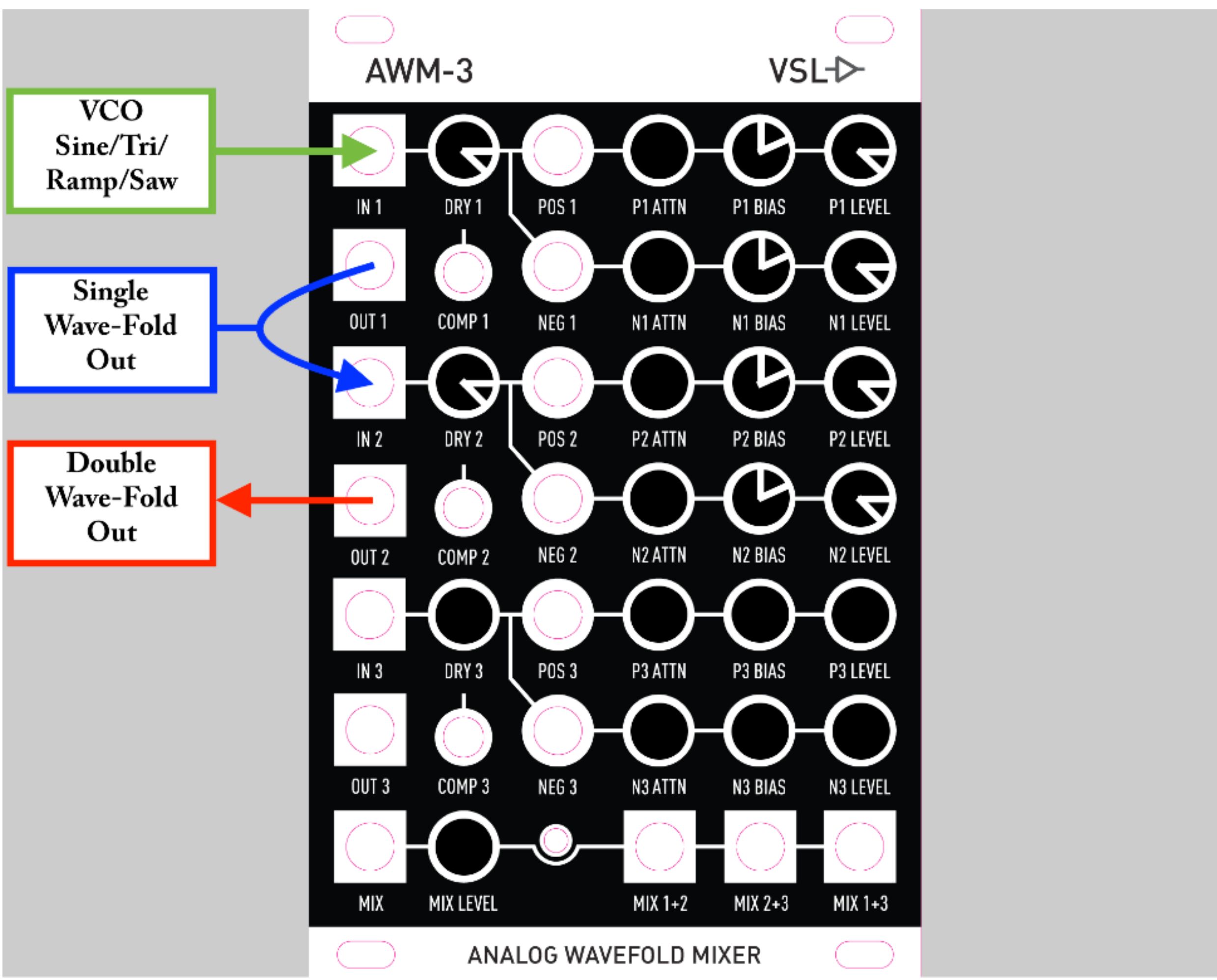
Let's set up the **AWM-3 as a Single wave-folder**…

1. Set the **DRY 1**, **P1 LEVEL**, and **N1 LEVEL** controls between 3:00 and 4:00 position.
2. Set the **P1 BIAS** and **N1 BIAS** controls between 12:00 and 2:00 position.
3. Connect the output of a VCO into the **IN 1** jack of the AWM-3 (directly into the AWM-3 for <u>static wave-shaping</u> -or- into a VCA using an Envelope Generator gating the VCA for <u>dynamic wave-shaping</u>, then into the AWM-3).
4. The **OUT 1** jack now serves as a Single Wave-fold output. The compression switch can be set in either position. If compression is engaged, the BIAS controls may need further adjustment.



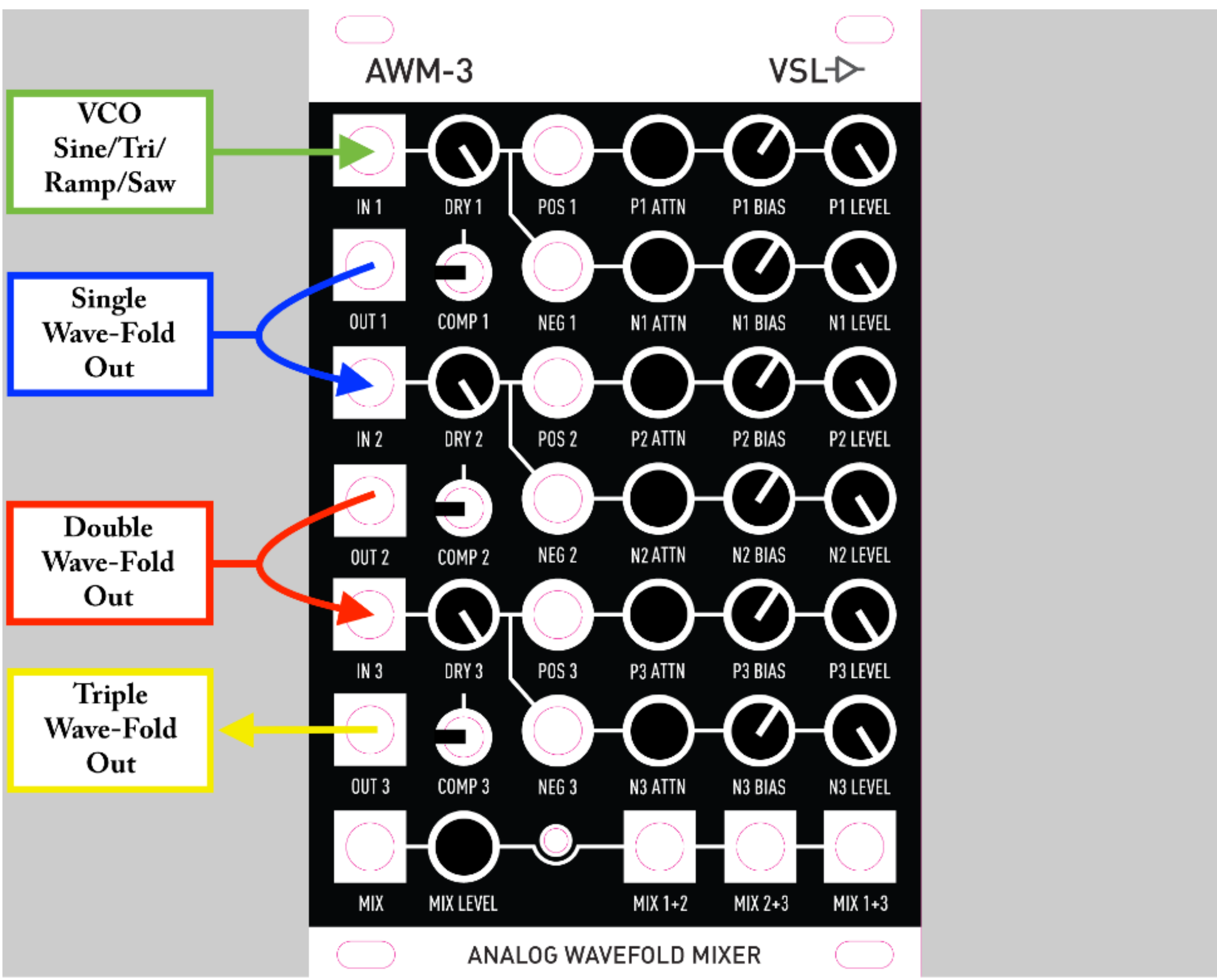
Let's set up the **AWM-3 as a Double wave-folder**…

1. Set the **DRY 1, DRY 2**, **P1 LEVEL, N1 LEVEL, P2 LEVEL, N2 LEVEL** controls between 3:00 and 4:00 position.
2. Set the **P1 BIAS, N1 BIAS, P2 BIAS, N2 BIAS** controls between 12:00 and 2:00 position.
3. Connect the output of a VCO into the **IN 1** jack of the AWM-3 (directly into the AWM-3 for <u>static wave-shaping</u> -or- into a VCA using an Envelope Generator gating the VCA for <u>dynamic wave-shaping</u>, then into the AWM-3).
4. Connect the **OUT 1** to **IN 2** with a patch cable (note: you can simultaneously "tap" into this connection as a Single Wave-fold signal with a splinter / stack cable).
5. The **OUT 2** jack now serves as a Double Wave-fold output. The compression switch can be set in either position. If compression is engaged, the **BIAS** controls may need further adjustment.



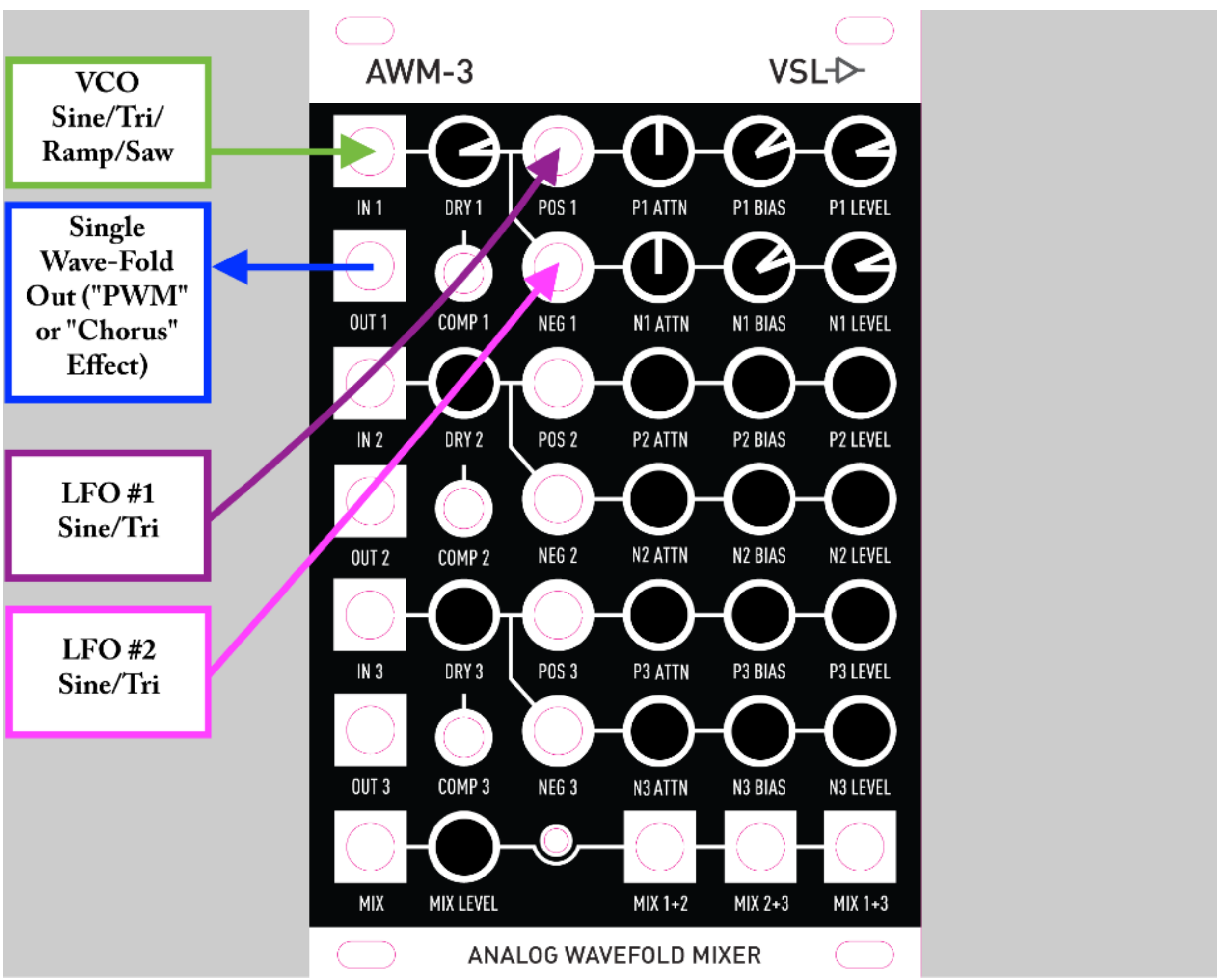
Let's set up the **AWM-3 as a Triple wave-folder**…

1. Set the **DRY 1, DRY 2**, **P1 LEVEL, N1 LEVEL, P2 LEVEL, N2 LEVEL, P3 LEVEL, N3 LEVEL** controls between 3:00 and 4:00 position.
2. Set the **P1 BIAS, N1 BIAS, P2 BIAS, N2 BIAS, P3 BIAS, N3 BIAS,** controls between 12:00 and 2:00 position.
3. Connect the output of a VCO into the **IN 1** jack of the AWM-3 (directly into the AWM-3 for static wave-shaping -or- into a VCA using an Envelope Generator gating the VCA for dynamic wave-shaping, then into the AWM-3).
4. Connect the **OUT 1** to **IN 2** with a patch cable (note: you can simultaneously "tap" into this connection as a Single Wave-fold signal with a splinter / stack cable).
5. Connect the **OUT 2** to **IN 3** with a patch cable (note: you can simultaneously "tap" into this connection as a Single Wave-fold signal with a splinter / stack cable).
6. The **OUT 3** jack now serves as a Double Wave-fold output. The compression switch can be set in either position. If compression is engaged, the **BIAS** controls may need further adjustment.



Let’s set up the **AWM-3 as a <u>mono</u> analog effect that is similar to either a PWM or Chorus type of sound**…

1. Set the **DRY 1**, **P1 LEVEL**, and **P2 LEVEL** controls between 2:00 and 3:00 position.
2. Set the **P1 BIAS** and **N1 BIAS** controls between 1:30 and 2:00 position.
3. Set all **ATTN** controls to the desired position of modulation applied to bias (start at 12:00 position).
4. Connect an LFO to the **POS 1** jack. If only this LFO is connected, the **OUT 1** will sound like a “PWM” effect.
5. Connect a second LFO to the **NEG 1** jack (this disconnects the **POS 1** feed “normalled” to the **NEG 1** jack), and the **OUT 1** will sound more like a blend of “PWM” *and* “Chorus” effect.
6. Connect the output of a VCO into the **IN 1** jack of the AWM-3 (directly into the AWM-3 for <u>static wave-shaping</u> -or- into a VCA using an Envelope Generator gating the VCA for <u>dynamic wave-shaping</u>, then into the AWM-3).
7. The **OUT 1** jack now serves as a Single Wave-folded output with an effect similar to “PWM” or “Chorus”. The compression switch can be set in either position. If compression is engaged, the **BIAS** controls may need further adjustment.



Let's set up the **AWM-3 as a <u>stereo</u> analog effect that is similar to either a PWM or Chorus type of sound**…

1. Set the **DRY 1**, **P1 LEVEL**, **N1 LEVEL** controls between 2:00 and 3:00 position.
2. Set the **DRY 2**, **P2 LEVEL**, **N2 LEVEL** controls between 2:00 and 3:00 position.
3. Set the **P1 BIAS** and **N1 BIAS** controls between 1:30 and 2:00 position.
4. Set the **P2 BIAS** and **N2 BIAS** controls between 1:30 and 2:00 position.
5. Set all **ATTN** controls to the desired position of modulation applied to bias (start at 12:00 position).
6. Connect an LFO to the **POS 1** jack. Set the **P1 ATTN** and **N1 ATTN** controls to apply various amounts of modulation to the P1 BIAS and N1 BIAS.
7. Connect another LFO to the **POS 2** jack. Set the **P2 ATTN** and **N2 ATTN** controls to apply various amounts of modulation to the P1 BIAS and N1 BIAS.
8. Connect the output of a VCO into the **IN 1** jack and the **IN 2** jack. These can be the same signal or a separate VCO waveform. (Patch directly into the AWM-3 for <u>static wave-shaping</u> -or- into a VCA using an Envelope Generator gating the VCA for <u>dynamic wave-shaping</u>, then into the AWM-3).
9. Connect a sub-octave VCO waveform into **IN 3**. Set the **DRY 3** control to the desired mix against the other two channels' levels.
10. The **MIX 1+3** and **MIX 2+3** jacks now serves as a stereo chorused single wave-folded set of outputs. The compression switch can be set in either position. If compression is engaged, the **BIAS** controls may need further adjustment.